THE AMERICAN GEOLOGIST

A MONTHLY JOURNAL OF GEOLOGY AND ALLIED SCIENCES

VOLUME XXXVI

JULY TO DECEMBER, 1905

MINNEAPOLIS, MINN.
THE GEOLOGICAL PUBLISHING CO.
1905

C. L. Herrick

THE AMERICAN GEOLOGIST,
VOL. XXXVI PLATE I

The portrait of Dr Herrick, vol XXXVI, plate I, was badly printed. The binder will please substitute this

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. JULY, 1905. No. 1.

CLARENCE LUTHER HERRICK.

By W. G. Tight. Albuquerque, New Mex.

PORTRAIT, PLATE I.

When a great and good man is taken from the midst of his life work and those whom he has served are called upon to realize their loss, there is ever a desire to perpetuate his memory and to preserve such knowledge concerning him as will be of further service to humanity. In preparing a fit memorial to Dr. Herrick the writer realizes his own inability to do justice to the man and his work. Perhaps no other outside of his immediate family was better acquainted with him than myself. Having lived with him in the home, in the camp, in the school room and laboratory and being in almost constant correspondence with him for a long term of years when circumstances separated us, his death is a very deep personal loss. Dr. Herrick has many pupils scattered over the world who feel that they owe much to him and in whom he took a very deep interest and pride. Of this large number there were two boys who were a little nearer to Dr. Herrick's heart than any of the others. Not because they were any better or brighter but because of the circumstances connected with their coming together. These two were Herbert L. Jones and myself. When Dr. Herrick went to Denison university in 1885 and started his career as a teacher he was a comparatively young man, being only twenty-seven years old, but his characteristic earnestness and enthusiasm were so manifest that he attracted to himself out of a graduating class of thirteen these two boys and through his influenee both remained at Denison for a year of post-graduate work. We were the first resident

post-graduate students Denison ever had. Prof. Jones devoted his life to the study of Botany, contributing several important articles to science. He taught science in the preparatory department of his Alma Mater for several years, was assistant botanist at Harvard for a time, resigning to accept the professorship of Botany at Oberlin college, where he served but one year, when called from his labors by Death, at the very opening of his career. It was because we two boys were first on his long list of devoted pupils that we were held with special regard by him. Yet in spite of the intimacy of my relations with him through all these years that have intervened it is with misgiving that I undertake the sad task of presenting this tribute to his life and character.

In order that my views may not be colored too much by my own personal feeling and sense of personal appreciation it is my purpose to express myself largely through the words of others and to present such views as have been given by them as will in my judgment bring out the salient features of Dr. Herrick's life and work. In a letter written to Rev. J. L. Cheney, Cleveland, Ohio, Sept. 27, 1904, his brother C. J. Herrick says: "His was a life very difficult for any one person to estimate, for his work was in so diverse fields that few men have even a speaking acquaintance with all of them. His life may be roughly divided into four periods. Very early in his career he seems to have laid out at least in a rough way a rather ambitious plan of action including for the first part of his life miscellaneous research and study in the broad field of general natural history—a general broad foundation. Then was to follow a period of intense specialization in the circumscribed field of zoological work leading up to a mastery of anatomy, and physiological and comparative psychology on the basis of the mechanism of the nervous system and to the philosophical correlation. So far as I am aware my brother never announced this or any other program, and I doubt if such a thing was ever definitely formulated even in his own mind; yet from some of his conversations which I remember years ago I believe that some such plan was in his mind. While the four periods referred to above were marked by extraneous events,

apparently artificial or arbitrary, yet I think it may be said that the ideal scheme was in the end fairly achieved, though with great deviation in the details of the working."

FIRST PERIOD. 1858-1884.

The son of a Baptist clergyman, Dr. Herrick was born near Minneapolis, Minn., June 21, 1858. He grew up in a home far from neighbors as a solitary child with few playmates and very early showed his bent for the study of nature. While still in the Minneapolis high school he collected extensively and left at graduation a case of over a hundred mounted bird skins and other specimens in the high school. It was during this period that his father got him an eight dollar microscope. With this crude instrument and without library facilities he worked over the fresh water fauna of the neighboring brooks and pools so thoroughly that before graduating from the university of Minnesota, in 1880, he had published several articles of value on the fresh water crustacea of Minnesota and four years after graduation, with somewhat better facilities, published a report on the microcrustacea of Minnesota which is still standard. These years and those of his university course were filled with many bitter struggles, not the least of which was with poverty and the lack of materials for study. But notwithstanding these, he completed his course in three years, at the same time partly supporting himself by assisting on the Minnesota natural history survey. He had also showed so obvious a native gift with his pencil that upon his graduation the president of the university said that he was uncertain whether to advise him to devote his life to science or art. But there was no uncertainty in the mind of the young man. Continuing his work with the geological and natural history survey of Minnesota after graduation, he published many papers in rapid succession on the fauna of the state and began an extensive report, the first volume of which was completed in 1885. This was a large quarto on the mammals of the state fully illustrated with many colored plates and pen drawings. It was accepted for publication, but for lack of funds in the survey, never saw the light. Years afterward, in 1892, a small octavo was published by

the survey made up of the more popular parts of this work. He spent a year in Leipzig at the University during 1881-'82. And in 1883 he was married to Miss Alice Keith, of Minneapolis.

He took his Masters and Doctors degree from the university of Minnesota.

SECOND PERIOD. 1884-1889.

Called to the chair of Geology and Natural History of Denison university, Granville, Ohio, in the summer of 1884, he spent the fall of that year at Denison, then returned to Minneapolis to complete the work begun by him on the Minnesota survey and in the fall of 1885 moved with his family to Denison. It had been his intention to continue his zoological work there, and there was great activity in this line during the entire period, but the routine excursions made as a part of the instruction of his geology classes showed him so much of interest in the local strata that his chief labors while in Granville, were upon the fossils and stratigraphy of the Waverly free stones and shales of Ohio. This work was abruptly cut short by his removal from Granville in 1889, and while never rounded out as he would have liked is probably his most important geological work. In 1885 he founded the Bulletin of the Scientific Laboratories of Denison university, in which the greater part of his researches and those of his pupils on Ohio geology were published.

His phenomenal success as a teacher during this and subsequent periods was due to factors some of which are easily seen—others hard to define. After his attractive personal qualities and magnetic enthusiasm I should place his deep philosophical insight and the fearless way in which he opened up his profoundest thinking to even his most elementary pupils. The ability to do this without befogging the air was an exceedingly rare gift and was stimulating to even a dullard. He knew the philosophical classics thoroughly from original sources and the trend of his thinking was very early foreshadowed in the translation of Lotze's Outlines of Psychology, published in 1885 in Minneapolis, with its appended chapters on the nervous system.

THIRD PERIOD. 1889-1894.

Upon his acceptance of the chair of Biology in the university of Cincinnati in 1889, the geological studies with which the preceding five years had been so fully occupied were summarily brought to a close and he threw himself with renewed energy into the study of the nervous system. Extensive papers on the brains of different animals appeared in rapid succession of which the most valuable are two series, one on the brains of various fishes, the other on those of reptiles. In 1891 the Journal of Comparative Neurology was founded and served as the medium of publication for most of these researches. The founding of this journal can best be designated as a piece of characteristic audacity. It was a purely private enterprise with no funds assured and very little outside co-operation promised. But without counting the cost he plunged boldly in, expecting a constituency to be developed as the work went on. In this he has not been disappointed wholly, though recognition of financial needs has lagged sadly behind that of the scientific excellence of the journal. At the close of 1891 he resigned his chair in the university of Cincinnati to accept a chair of Biology in the university of Chicago, then being reorganized. The early part of 1892 was spent in Europe, chiefly in Berlin. Upon his return the adjustment at Chicago presented unexpected difficulties and after a series of misunderstandings he withdrew from the institution, declining an offer to return to Germany for further study on full salary. He was immediately elected to his old post in Denison university with an assistant and the privilege of devoting only a part of his time to teaching, the remainder to be spent either at home or abroad in the further prosecution of his research. A year and a half of great productiveness followed. He bought a small tract of land adjacent to the college campus, built a residence upon it and planned to devote the remainder of his days to breeding animals on an extensive scale and studying the laws of heredity, comparative psychology and allied problems. But before this project was fully under way his health broke down and he was forced to abandon his home in the fight for life.

In December, 1893, he had a severe attack of la grippe,

but as was his custom in illness went on with his work as usual. Upon completion of the last examination of the term he came home too ill to correct the papers, and in the course of the following night was attacked by a severe hemorrhage from the lungs and for weeks his life hung in the balance. With the return of spring his strength increased sufficiently to enable him to remove to New Mexico, where the local physicians told him he had a fighting chance for a few years. He accepted the challenge bravely and for more than ten years held the disease in check. During the spring of 1894, the college dedicated the Barney Science Hall, which had been built largely under the stimulus of his presence in the faculty, but he was never permitted to work in it.

FOURTH PERIOD. 1894-1904.

This decade, filled with bodily pain and the worse torture of anxiety and mental unrest, is yet one of the most productive periods of his life. Much of the time was spent in the open with covered wagon and camp kit, and with the return of strength scientific interests again absorbed his attention. Naturally in this case he again turns to geology and an extensive series of articles on the geology of New Mexico, bears testimony to the industry of these apparently aimless wanderings. The first scientific work done in the territory was a revision of his earliest important work, the Crustacea of Minnesota. As soon as his geological knowledge became known his services were in demand as a mining expert and during the later years of his life in the territory he supported his family chiefly by practising this profession as strength permitted. For four years he was the president of the territorial university at Albuquerque, though at the close of the third year it became evident that the strain of the executive work and confinement were too hard for him, and his connection during the fourth year was mainly of supervision and general control. During his last year there was an obvious failing of physical strength so that long field trips had to be abandoned. But the more quiet life gave opportunity for a thorough recasting of many questions and formulation of matters which had been in his

mind all his life. So that before his death much of the philosophical correlation of which mention was made in his early life, was effected. A number of articles have already been published in the philosophical serials bearing on these matters and there is a considerable collection of MSS. remaining, much of which can doubtless be edited for publication. It is gratifying to know that he had the satisfaction of seeing this work so well rounded out before his death and that the later months of his life were much more restful than those preceding, some of which were marked by extreme suffering.

He continued in about his usual health until Sept. 8, 1904, when he again had a series of uncontrollable hemorrhages, daily becoming weaker until on the morning of the 15th, he peacefully passed away.

His life work having been distributed in three widely separated communities, each gave expression of its estimate of the man at the time of his death.

The university of Minnesota knew him directly as a student and young investigator and his friends there have watched his subsequent career.

The Minnesota Magazine for October, 1904, contains the following notice:

"University men and women will regret to hear of the death of Prof. C. L. Herrick, at Socorro, New Mexico, September fifteenth. Mr. Herrick was graduated from the university, and had here been granted the degree of Doctor of Philosophy. Specializing in ornithology, he mounted many of the specimens now in the Biological Museum, and made scientific reports one of which was published for the state by the geological and natural history survey; and another an illustrated treatise on Fresh Water Crustaceans, ranks high among American authorities.

"As professor of Natural History in Denison university, his activities widened. He established the Journal of Neurology, one of the leading scientific periodicals of the world. He gave much attention to the geology of Ohio, and was for some time associate editor of the AMERICAN GEOLOGIST, to which journal he made extensive contributions.

"The university of Chicago offered him a professorship,

the duties of which he never assumed. Ill health compelled him to seek the more favorable climate of New Mexico, where after a short service as instructor in the school of mines at Socorro, he was elected president of the university of New Mexico, at Albuquerque. Here his zeal and energy so inspired his associates that the university entered upon an era of activity unusual in so young an institution. His health, however, continuing to fail, Dr. Herrick was forced to resign the responsibilities of the presidency and seek the more active outdoor work of a practical geologist and irrigation engineer. So employed and continuing to contribute to the scientific journals, he labored industriously until his death. His last paper appears in the current number of the AMERICAN GEOLOGIST.

"Few alumni of the university of Minnesota have attained higher rank among the American scientists. Three commonwealths feel the influence of his versatile brain; three universities honor his memory. For years he labored under the discouragements of disease, but he held out gallantly in the prosecution of his chosen work. All his intellectual life was given to the abstruse problems of science, and his achievements should place him among the savants of the opening century."

In Ohio "The Granville Times" and "The Denisonian" the weekly college paper, both published portraits and extended articles concerning him and his life work.

The Denison Scientific Association held a special memorial service at which Prof. G. F. McKibben of Denison, Prof. A. D. Cole of Ohio state university and Prof. Aug. F. Foerste of Dayton, Ohio, made the principal addresses.

Prof. Cole said in part in his address on "C. L. Herrick as a Maker of Scientific Men," published in a special memorial volume of the Bulletin of the Scientific Laboratories of Denison university.

"I desire to emphasize especially his rare power of influencing young men—and that too without seeming to make any effort to do so—to adopt his own point of view of life and devote themselves, wholly or in part, to the quest of truth which was to him the great thing in life. This seems to me to be the most striking and characteristic

thing in professor Herrick's personality. He was learned, but we have known others learned too; he was devoted to his work but such devotion, though uncommon, we may find elsewhere; he was a rare teacher, but the country has many great teachers; he was a man of strong religious faith and rich Christian life, but that too we may parallel in other lives. But I cannot think of one other man who so powerfully impressed those with whom he came into any sort of contact with a real longing to find out new truth by their own effort and add it to the legacy of knowledge which the present generation has inherited from the past. His own work as an investigator was great; his work as a maker and trainer of investigators was perhaps greater. I have never known an enthusiasm so contagious as his. It is no mere accident that both his brothers, his wife's brother, his only son and a large proportion of his students have caught the spirit of original research and made important contributions to the fund of new knowledge. Contact with him in class room, laboratory or household seemed equally efficient for propagating the germ of personal investigation. He might have been a great teacher even without this power, as others have been; with it his success was assured and eminence certain with favorable conditions. * * * What were some of the reasons for the unquestionable power he possessed of moulding the purposes and lives of his associates?

Let us note at least a few of them. One reason for this power was undoubtedly the perfect sincerity of his devotion to science. It was so apparent from even a slight acquaintance with him that he loved it and believed in it as a pursuit worthy not only of his own highest thought and most earnest effort, but deserving as well the supreme attention of any man. He was not given to proselyting; there was no direct appeal to others to interest themselves in those things which he pursued. But given a noble mind, despising the shams which it already sees constitute so large a part of modern life, longing vaguely to realize its youthful dreams of mental achievement and moral victory, in close daily contact with an enthusiasm so pure and unselfish as that of professor Herrick, is it any wonder that the ambition to

emulate him should be kindled in that mind? We all know the teacher, who seems to teach for "what there is in it for himself"—such small return of money, social position or reputation as seems to be attached to his business; we have seen how he bolsters up his own dead interest in the progress of science by sounding phrases about the dignity of scientific pursuits. No one recognizes the sham more quickly or completely than the students in his class room, and with the recognition his power as teacher is gone. No one can interest another in an intellectual problem in which he himself is not genuinely interested. Even if he believes himself interested, that is not enough; self-deception cannot save him. His students will feel—vaguely perhaps, but surely—that the interest is not real. On the other hand the teacher with a genuine zeal for his subject, so simple that it never feels the need of self- assertion, already has his battle two-thirds won. The student unconsciously detects the real article as well as the sham. As it is hopeless to deceive students by the parade of simulated enthusiasm, so it is unnecessary to proclaim the real one. Thus professor Herrick's intellectual honesty and genuine zeal for science found an answering note in the minds and hearts of all those whose lives touched his. We who knew him felt our own ambitions purified and ennobled by the contact.

Secondly, his remarkable industry emphasized the effect of his sincere devotion to science. He was not one to tell how much midnight oil he burned or in any way indicate the intensity of his labors, but both their quality and quantity compelled our attention and we watched and found that he rarely spent an idle minute. Not only were his working hours long, but intensely active. Many of us remember the long quick stride which carried him so rapidly from task to task; it was an index to the energy of the mental machine within.

A letter recently received from a former student who was for a time a member of his household says: "The tireless energy of the man was inspiring. His light was last to go out in the home and on going to breakfast early in the morning it was no unusual thing to meet professor Herrick returning from the woods or swamp with a supply of

material for the day's classes * * * If he ever took a rest we never knew of it."

A third reason for professor Herrick's ability to instill the spirit of research was found in his subordination of most of the common aims which move men to what was evidently the great aim of his life. * * * Professor Herrick, while remarkably faithful to all of his duties to others, managed to give such emphasis to his scientific labors that it became but natural to think of him always as a man-of-science.

Another thing that attracted students and led them unconsciously to seek to imitate him was the freshness and originality of his ideas. His mind was always taking conventional and commonplace ideas and making something fresh and new out of them. He thought much of the philosophical bearing of scientific things. "The Psychological Basis of Feelings," "Psychological Corollaries of Modern Neurological Discoveries" are two of the many titles of his scientific papers indicating his tendency to philosophize the results of his scientific observations.

Besides the four mental traits which I have mentioned in attempting to account for the power he possessed of energizing others into scientific activity there were moral attributes which contributed more to the same end.

One of these was connected with his originality and mental independence, namely his courage in over-riding false traditions and calmly undertaking the solution of difficult problems. His was the pioneer type of mind. And so he frequently introduced novel methods in his teaching which aroused attention and interest. Although his connection with Denison was not a long one, he introduced at least four striking innovations which have already stood the test of years and bid fair to be permanent. These were (in chronological order) The Scientific Association, the Bulletin of the Scientific Laboratories, The Neurological Journal, and the courses of study which lead to the degree of Bachelor of Science at Denison.

At the time of its introduction each one of these innovations seemed to be a questionable proposition, hardly likely to succeed. * * * He started the first volume of the

Bulletin of the Scientific Laboratories the year following his coming to Denison. * * * There are eighty-five articles written by many different authors, most of them Denison men, students or faculty members, and not a few of them those who have become original workers through the influence and example of professor Herrick himself.

Undoubtedly its success has been due to the fine start it made through the unremitting labors of professor Herrick as editor. Of the 26 articles which constitute the first four volumes issued under his editorship, no less than ten were from his own pen. And after ill health compelled him to seek another climate, and in spite of the fact that he had taken the editorship of the Journal of Comparative Neurology upon his hands we find him a frequent and valuable contributor. So late as June 1900 (in Vol. XI.) we find an elaborate article of more than sixty pages, with a map and 34 beautiful plates for which he was so well known. * * * In 1887 professor Herrick founded the Denison Scientific Association whose object, aim and history during seventeen years are well known to most of you. Very faithfully has it carried out its aims as he expressed them in its constitution "To collect, record and disseminate information bearing on the sciences and to stimulate interest in local natural history and preserve specimens illustrating the same." I think very few of those who tried to help him start the Association expected that it would continue and develop as it has done. My own feeling concerning it is well expressed in a letter recently received from another of its charter members, professor J. E. Woodland of the Rochester Athenaeum and Mechanics Institute. He says:

"I recall vividly the organization of the Denison Scientific Association and the enthusiasm with which professor Herrick directed the work and gathered the material for the programs. I have been associated with other Scientific Associations since then but have yet to find the genuine local interest and enthusiasm that characterized the one in Granville."

The fourth innovation due principally to professor Herrick, was the complete revision of the work in science in the course of study leading to the B. S. degree

at Denison. * * * It was another case where professor Herrick's independence of tradition led to important results for Denison.

A sixth reason for professor Herrick's ability to arouse the spirit of scientific research in others we find in the breadth of his interests and sympathies. He did not follow the fashion of extreme specialization so characteristic of our time. Before he came to Denison he was state mammalogist of Minnesota, at Granville he was botanist, zoologist, geologist and neurologist, not merely teaching but investigating along these lines. While in New Mexico he added work of a mining engineer to that of geologist and neurologist, and in his last months we hear of his resuming study and writing along philosophical lines, a labor which had been begun many years before. And so under his tutelage we find one of his students inspired to become a botanist, another a biologist; several became geologists and others neurologists. And to all he was able to extend such counsel, stimulus and sympathy that his influence became one of the determining forces of their lives

And this brings us to the last reason that I will name to explain professor Herrick's power over his students; namely, his personal interest in them, not alone in their scientific development, but in all their joys and troubles. Quoting again from Mr. Woodland's letter, "To the student he was never a professor with awe-inspiring dignity, but rather a companion and friend. * * * There seemed to be some great pressure incessantly driving him to work, yet with it all we never entered his room that he did not make us feel entirely welcome. * * * He never spoke a word of discouragement to any one."

And now in conclusion let me illustrate several of these sources of professor Herrick's power to inspire students by reading to you a letter which I received to-day from W. E. Castle, now professor of zoology in Harvard university, one of the many young men who honor professor Herrick's memory in the highest possible way, by following in his foot-steps.

"While in conversation with a zoologist from a distant state I was asked from what college I came. 'From a col-

lege' I replied 'of which very likely you never heard, Denison.'

" 'O yes,' was the prompt reply, 'I know Denison; the Herricks have made Denison famous.' " This incident gives evidence of the high regard in which the scientific work begun at Denison by professor C. L. Herrick is held among workers elsewhere in similar lines.

From an article in the same Bulletin by H. Heath Bawden we quote: Of professor Herrick's contributions to philosophy a word should be said. That his interest was a deep and abiding one is abundantly evident from a glance at his writings which include many articles and discussions dating from the publication in 1882 of his translation of Lotze's lectures on psychology to the series of articles on "Dynamic Realism" which he had begun to publish in the Journal of Philosophy, Psychology, and Scientific Methods, at the time of his death. He made frequent short contributions to the Psychological Review, besides publishing various other articles of a psychological and philosophical character in his own journal. His interest in problems of ethics and religion is evidenced by diverse articles in certain of the religious periodicals as well as much unpublished manuscript.

Of his metaphysical writings it should be said that they were always inspired by his scientific researches. He never was satisfied with the easy philosophy of the "anti-metaphysical" standpoint of many fellow scientists. Psychophysical parallelism he regarded as "the Great Bad." The aim of his life was to throw light upon just such so-called insoluble problems as the relation of consciousness to the brain.

"Ignorabimus" is a word which never fell from his lips. The unity of the material and the mental is a truth upon which he came to lay increasing stress in his later years. Starting from a Lotzean spiritualistic idealism he never lost hold of the monism which characterizes that philosophical world-view, though in many respects he worked beyond it, his scientific studies serving to correct any tendency to an exclusive emphasis upon the mental. This is seen in the title under which his latest writings appear—"Dynamic

Realism"—in which many will find hints of a coming philosophic movement which is to reinterpret the fixed ontological categories of a past metaphysics in more dynamic and organic terms.

Of his contributions to the theory as to the nature of consciousness (equilibrium theory of consciousness), the physiological basis of the emotions, theory of pleasure-pain (summation-irradiation theory of pleasure-pain), his discussion of the reflex arc or organic circuit under the terms of his own coining ("aesthesodic" and "kinesodic") and in general his interpretation of experience in dynamic and energic terms, we may not here speak in detail. But the attention of the readers of this Bulletin should be called to this side of his work as it is embodied in his various published writings and especially in certain writings which are yet to appear."

In the memory of his pupils professor Herrick was greatest as teacher. This statement can only be appreciated by those who knew him personally and were in his classes. There was no display or oratory. He was not what would be called a gifted public speaker, though he was often called upon for such services. It was in the class room or about the seminar table or in general conversation that the inexhaustible fertility of his thought and fine suggestiveness of his language appeared. In his lectures one always knew that he was getting the best, the latest, the deepest results of his scientific research and philosophic reflection. Never was any work slighted in which his students were involved. Other things might be sacrificed—time, money, convenience, even health itself, but never the student. The result was that his teaching was not confined to the class-room or laboratory. There never was an occasion upon which he was not ready to suggest, advise, assist the groping mind in search for truth.

He was extraordinarily versatile in the class room. He would lecture with a piece of chalk in each hand, sketching at the same time ambidextrously upon the blackboard the figure he was describing. Never did the lecture degenerate into a mere description of the figure. The figure he was describing was the figure in his mind—the figure that he

was thereby suggesting to the student's mind. Such description and all the other instrumentalities of the classroom and laboratory were always kept in their proper place and proportion as means to the end of knowledge and insight. His artistic sense was too fine to allow them ever to degenerate into mere ends in themselves; the technique of his teaching was in itslf a work of art, the more that it was unconscious on his part. His courses in neurology, embryology, and histology were primarily courses in thinking. This is no doubt the reason why so many of his students look back upon his teaching as a period of their intellectual awakening."

One of his colleagues at Denison university says of him: "All who knew professor Herrick loved him. Different friends had different reasons for loving him, but all agreed in loving. Christian people loved him because he was a loyal Christian man. Intellectual people loved and admired him because of his brilliant and keen intellect; and men in general loved him because they saw in him a true and noble man loving the truth and living it out in his daily life."

As has been said of another: "He did his work with a quietness which concealed its power. He contributed to science our best example of the scientific temper. He was a profound thinker. He was a successful teacher. He was a lover, inspirer, and leader of youth."

Being so intimately acquainted with Dr. Herrick and his family it was my privilege to see many of the letters of sympathy and appreciation which were addressed to the bereaved wife and quotations are made from a few of them which refer directly to the characteristics of Dr. Herrick.

"* * * Dr. Herrick was a great man. Had his health been kept good through the last ten or more years his work and writings would have shown even more clearly the caliber of his mind, and the later years of his life would have been honored as few American scientists are honored.

"I count myself fortunate in having known him so well. As a youth he brought me at the university of Minnesota, some natural history specimens of his own preparation.

That resulted in his being employed on the survey, and in his working up some of our material. After his departure for Granville I only knew of him by his publications. But the fruition and the scientific acumen displayed in his writings fully bore out the estimate I formed when I first came to know him. He has left a beautiful and honorable record of which his children may be proud.

N. H. Winchell."

" * * * I cannot resist the desire of saying a word concerning Dr. Herrick's later years in New Mexico. When I went to the southwest it was Dr. Herrick's presence that drew me thither. For several years I knew him as my teacher in geology and biology, as an inspiring companion in camp and field and as a faithful friend and advisor in every emergency. He welcomed me not only into his classes but into his home as well; and I came to know him as the teacher, the student, and the man.

"His work in New Mexico formed the most splendid exhibition of what heroic courage and unfaltering will power can accomplish in the face of obstacles which are usually regarded as insurmountable. Broken in health, his body wasted by the disease to which he had fallen victim, he nevertheless worked on with tireless energy, accomplishing the impossible by sheer strength of will. Those who have not known of the conditions under which his work was accomplished can never realize all that it represents. They see the finished published report; but not the man rising from his bed, within an hour after a hemorrhage from the lungs, to tramp across the foot-hills to his work. They see the report of a geological reconnaissance; but not the writer struggling up a steep mountain slope, straining every nerve and muscle, until he feels the approach of another hemorrhage; dropping at last with exhaustion to wait for what he believes to be the end, and lying there on a hastily made bed, under a drifting snow, through a night so cold that all the provisions were frozen, but rising next morning to press on through one of the worst snow storms that ever swept the Manzana mountains. This I have seen and marveled that human endurance could last so long. And were the truth told about all the suffer-

ings on thirsty plains and storm-swept mountains, undergone by him who was not able to bear the least of them, that truth would seem almost incredible.

"Through it all there was an enthusiastic devotion to his work which inspired every one with whom Dr. Herrick came in touch. I believe his students will agree that he had a rare ability to enlist enthusiastic interest in everything he did. Whether in the class-room or around the camp fire his hearers were inspired with a new desire to know more about the wonderful truths of nature of which he talked. This essential quality of the successful teacher he had in the highest degree. * * * I wanted to say at least one word to you about him to whom I owe more than I can realize.

D. W. Johnson, Dept. of Geology.
Mass. Institute of Technology."

These few quotations will give an idea of the high esteem in which Dr. Herrick was held by those who came into personal contact with him. I know of no better word to express the general characteristic of the man than one which I have heard often used in reference to him, and which he has used often to me in reference to himself, and that is "pioneer." A pioneer in every sphere of his activity, it was his task to lay foundations among the difficulties. In material things he organized the first laboratories in Denison University in biology and geology. He was instrumental in the construction of the new science building "Barney Memorial Science Hall," yet he never was to work in its laboratories. When overtaken by sickness and it was known that he must leave Denison some of his "boys" went to his house with a closed carriage and took him to the Barney Science Hall and carried him through the fine laboratories he had so carefully planned, in their arms, and he remarked that he believed that he knew how Moses felt when he was permitted to view the promised land. The same thing was experienced at the university of New Mexico. He started his work there in a few meagre rooms, was instrumental in the erection of the Hadley Science Hall, but was not permitted to labor in its laboratories.

In the intellectual field it was the same way. His

studies and publications on the Waverly of Ohio, while extensive, were, as he says himself, only preliminary.

In the field of biology and philosophy it is the same. He has opened up the path and pointed the way for others to follow. Yet in spite of the great diversity of directions of his mental activity he has manifested the true pioneer instincts and his vision into the future development and possibilities of each field of study has been clear and certain.

I believe the surest test of greatness when applied to his life work will show that as time goes on his work will be more largely appreciated and his service to the cause of science and humanity will be more clearly recognized.

His devoted wife, one son grown to manhood and two daughters survive him; the latter all in school or college and far away at the time of his death. The funeral service in his home at Socorro was simple, just as he would have chosen, but on the following week, all departments of the university of New Mexico united in a most fitting memorial service at Albuquerque, where those who had known him intimately for years paid high tribute to his worth.

To have known the man was to love him. To have felt the power of his influence and earnest enthusiasm in his work was to have gained an inspiration for a life-time.

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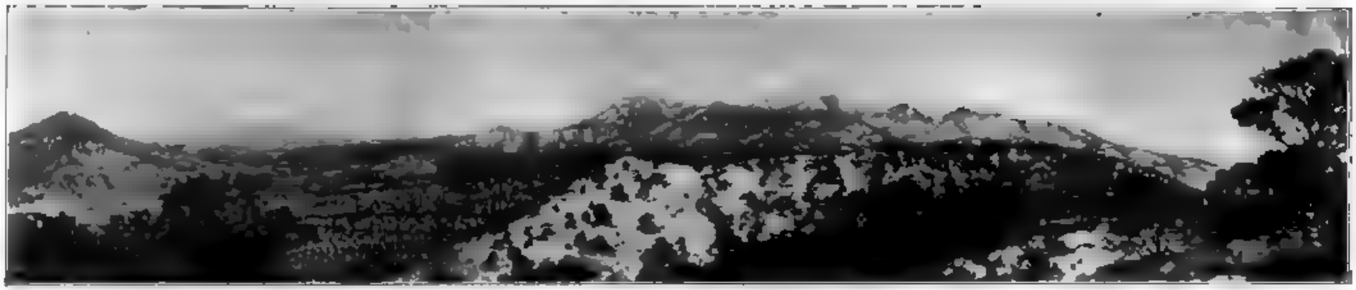

THE ORTIZ MOUNTAINS.

THE HIGH ALTITUDE CONOPLAIN; A TOPOGRAPHIC FORM ILLUSTRATED IN THE ORTIZ MOUNTAINS.

BY IDA H OGILVIE, PH. D. ROCKLAND, ME.

PLATE II.

During the past winter the writer was engaged upon a somewhat detailed survey of the Ortiz mountains, New Mexico. These mountains are in the central part of the territory, some twenty-five miles east of Albuquerque, and somewhat farther southwest of Santa Fé. The region proved to be of unusual interest from the three separate points of view of physiography, petrography, and palæontology. A full report on all of these subjects will be published elsewhere, the present paper touching only upon certain physiographic points of general interest.

The Cordilleras of North America in Mexico and for one hundred or more miles north of Mexico, consist of many ranges. These ranges are various in length, hight and direction, but the general trend of the Cordilleras as a whole is N. W.—S. E. The ridges are generally steep and are separated by flat plateaus. The general surface of the plateau region is rarely less than 6,000 feet in altitude, although in some cases rivers have cut below the general level.

Near the 34th parallel the Cordilleran belt divides, one portion trending northward, to and beyond Colorado, the other portion running westward and then northward through Arizona and Nevada. These form respectively the Rocky mountains and the Basin ranges. Between them lie the great plateaus.

Bordering the Cordilleran country are many volcanic areas. The eruptions vary in age and in type, extending from shortly after the close of the Cretaceous to nearly recent time, and including volcanic cones, extrusive and intrusive sheets, dikes, necks and laccoliths. The volcanic region is confined to the borders of the Cordilleran belts.

The Ortiz mountains lie within this borderland, in the eastern branch, not many miles north of the point where the ranges fork. They are laccolithic in origin; post-Cretaceous and probably pre-Pliocene in age. West of the

Ortiz are the Sandia mountains, a range of the basin type whose steep western face marks a fault scarp with a throw of over 4,000 feet. On the east the Sandias have a gentle slope and the beds dip gently east. The gentle easterly dip persists for many miles, and across the edges of these dipping beds a plain has been cut. The plain is not perfectly flat but has irregularities due to two causes. One of these is the Rio Grande and its tributary, Galisteo creek, which have begun to dissect the plain; the other the difference in hardness of the various rocks cut, the edges of hard beds standing up in cuesta-like scarps. The hardest beds in the region are igneous sheets, derived from the Ortiz mountains.

The Ortiz laccolith was intruded after the strata were tilted to the east. Its cover has been largely removed by erosion, and the tops of the central and highest mountains (whose altitude is a little short of 9,000 feet) consist of the igneous core. Across the edges of the surrounding strata a plain has been partly built and partly cut, this plain sloping away from the laccolith on all sides. Because of its outward slope in all directions this form is here named a conoplain, and its slope is partly cut and partly built. This conoplain becomes continuous below with the general level of the region, at an altitude of about 5,800 feet. The conoplain has been cut alike across the Cretacic beds and the igneous sheets, and upon its surface has been deposited alluvial material (the Santa Fé marl of Hayden). It is not to be understood that this plain is a smooth surface with the configuration of a cone; on the contrary the harder beds stand above the soft to the extent of upwards of a hundred feet. But a line drawn from the central mountains outwards in any direction will pass over a surface cut on the surrounding rocks and sloping upwards towards the mountains. It is confidently believed that such a form is the normal one in a mountainous arid region, differences of topographic age being marked by differences in slope.

The difference in altitude between the mountains and the surrounding plateau (a difference of about 4,000 feet) is sufficient to produce a marked difference in precipitation. Vegetation is the measure of precipitation. The mountains catch the rain, and are in consequence forest-covered, with

such types as Pinusponderosa (var. scapulorum), Quercus undulata, and various shrubs of the oak and holly families. Associated with these are the cactus-like types, Opuntia, Cereus and Yucca. The vegetation is thus, for an arid region, a considerable one. The surrounding plains present a marked contract; Opuntia, Cereus and Yucca, together with Artemisia (sage brush) form the prevailing types. The largest trees there are pinon and a small cedar.

The result of this difference in climate is that the mountain springs give rise to streams which disappear entirely a short distance from their source. Within the Ortiz area there is no permanent stream which finds its way to the sea. For the greater part of the year the arroyos are entirely dry, and many of the springs dry up also. But when rain comes, it comes in quantities, and a few days of storm will start raging torrents.

The details of the idea of the growth of river valleys and of cycles of erosion have been developed in regions of moderate climate and of equably distributed rainfall. It is evident that in such a region as the Ortiz the normal erosion cycle will be markedly different. Leaving aside for the moment the larger question of the origin of the great plateaus, and also the special case of the Ortiz mountains, let us consider the theoretical erosion history of an ideal laccolith.

If we imagine a symmetrical laccolith of homogeneous rock, to have arched up the strata of previously horizontal rocks, the initial stage of erosion may be compared to that of Prof. Salisbury's homogeneous, symmetrical island. But with this difference that in the case of the island the limit in down-cutting is a result of checked velocity and is at sea level; in the case of the laccolith the limit is formed by the point at which the streams disappear, and may be at any altitude.

The transporting power of a stream depends upon volume and velocity. An increase in volume increases the transporting power by more than a simple ratio; velocity depends upon volume and declivity; hence an increase in volume indirectly adds to the transporting power by increasing the velocity. And an increase in declivity aids the

transporting power by more than a simple ratio. These facts were brought out thirty years ago by Gilbert in his classic memoir on the Henry mountains.

The amount of corrasion which a stream can perform depends upon its load. The transported detritus forms the tool with which it cuts, but an excess of material prevents corrasion. When a stream has all the load it can carry, the entire energy is used in transportation, and there is none for corrasion. If there is an excess of detritus, the transporting power is insufficient and deposition takes place. When a stream empties into a body of standing water its velocity is checked, material is deposited and further corrasion is impossible.

The ordinary peneplain, of Powell's type, is produced as a result of checked velocity. On emptying into the sea a stream's velocity diminishes, it deposits material, and its valley widens by weathering. When several valleys widen at the expense of the interstream areas a flat is formed, and this gradually extends upstream, until a peneplain is produced. But the initial cause of these results is checked velocity and that alone.

The energy of a stream depends not only upon velocity but also upon volume. Obviously a decrease in volume would also lead to deposition and to a cessation of corrasion. Such a decrease in volume might take place in various ways; but the common way in the plateau region is when a stream in its course passes from a less arid to a more arid climate. In the case of our ideal laccolith the rain would all be caught near the summit, streams would become established which would flow down the slopes, and on reaching the arid surrounding plain these streams would speedily dry up. This result would be accomplished partly by evaporation and partly by soaking in, as a result of the lower ground water level.

In the case of the laccolith, the process is aided by lessened declivity. The form being a constructional one, pushed up out of a previously existing plain, there would be a change in grade in passing away from the slopes of the mountains. This decrease in declivity would produce a corresponding decrease in velocity. Hence lessened volume

and lessened velocity would work together to produce deposition at a point near the edge of the disturbed area.

If the rainfall were equably distributed the point of disappearance of streams would gradually move nearer the mountains as more material accumulated. The theoretical end of the cycle would come when the laccolith became so far reduced that it could no longer catch the moisture, and wind alone would carve its surface. This old age laccolith would in a general way resemble the mature island; it would have slight elevation, be carved by radial valleys, and would be surrounded by a cut plain sloping gently away on all sides, this in turn being surrounded by a built plain. The whole would be closely analogous to the sea level forms of peneplain grading seaward into stratified deposits.

But in the region under consideration this ideal cycle probably never took place, since it would normally be interfered with by the two factors, unequal annual distribution of rainfall and wind.

The effect of the unequal distribution of rainfall is analogous to that of an oscillating coast. Given a coast that is alternately rising and sinking, no peneplain will be produced. If an approximation towards it develops, a slight uplift will rejuvenate the streams causing them to incise steep-sided channels; a slight sinking will drown the streams and fill their channels with deposits.

Similar processes are normally going on in the degradation of a laccolith. The burning heat of summer pushes the point of disappearance nearer the mountains, and even most of the springs go dry. At some uncertain period in the fall or winter, rains come and then torrents rush down rapidly cutting through the previously formed alluvial deposits, redepositing them farther out on the plain. These mountain torrents often change their courses entirely from one season to the next, the course depending upon the more or less fortuitous arrangement of the surrounding alluvial material. Therefore the surrounding conoplain is deeply scarred with arroyos and there are more arroyos than are ever full at any one time. Hence in no stage of the actual erosion cycle is the conoplain absolutely flat. In all stages it will be cut by gullies, but surface inequalities will be largely obliterated by filling with alluvial deposits.

In the usual erosion cycle in a moist climate, deposition is a mark of increasing age. There are notable exceptions, but in the typical, normal case a flood-plain is formed after a considerable amount of down-cutting has been done at the mouth of the stream. In the laccolithic cycle deposition takes place at all stages and in all places except the uppermost slopes. For if, after a rain, a flood stream extends its course two miles onto the plain and there dries up, for the last mile and a half or so it will have been losing volume and velocity and will have been depositing its material either as a flood plain or as an alluvial fan. If a few days later it has shrunk in volume and extends only one mile onto the plain, its transporting power will have decreased throughout its length and deposition will be taking place at the edge of or within the mountains. As the stream continues to shrink, its transporting power decreases until material is dropped well within the mountains. This deposition of material is a normal feature of all stages of the erosion cycle, though obviously more material will have been deposited when old age is reached than in youth.

The form taken by the alluvial deposits is somewhat diffierent in the two climates. The general process of cut and fill is the same for both, but the surface configuration differs. An old valley emptying into the sea develops flood plains along its lower course and also a delta at its mouth. These deposits are laid down in standing or in slowly moving water.

The banks of the river are still higher than its channel and the flood plain is a sort of filling dropped into the bottom of a curve concave upwards. The laccolithic deposits are as a rule built up on a flat with no pre-existing valley, and they take the form of alluvial fans. The confluence of several fans from neighboring streams may produce a plain.

In the normal erosion cycle in a humid region the cross section of the valleys changes from a steep sided V in youth, to a gentler sloped U in maturity. In arid regions the U shape never comes. If the valleys widen, it is by the retreat of nearly vertical cliffs. The reason seems to be that moisture and its results, soil and vegetation, are at

a minimum, hence there are no causes to produce the softening prominent in an eastern landscape. And when water is present at all, it comes in sufficient bulk to produce a torrent of large volume and high velocity. Such a torrent anywhere would cut steep-sided canyons, provided only that the rock cut into is sufficiently hard to stand in cliffs. In many cases joints are present which cause the rock to break off in blocks leaving cliff faces. So in the erosion cycle of our laccolith, the plain will not only be scarred at all stages, but it will at all stages be cut by steep-sided canyons.

Another interference with the ideal cycle is the wind. No one who has seen the whirlwinds moving over the deserts of Sonora or Chihuahua can feel any doubt as to the great possibilities of wind as an erosive agent. The general effect of wind upon a region such as the one under consideration would be the removal of fine material, thereby lowering the plains, the scarring of the hard rock by mechanical abrasion, and the drying of the soil.

Such may be considered the normal factors of erosion, but the cycle in nature is usually interrupted, or has abnormal conditions at the start. Among the interruptions may be mentioned vulcanism, the presence of some large river flowing to the sea, and climatic changes. For if some river is near enough to be reached by the streams, the laccolith at once becomes a part of the drainage basin of that river and its cycle is limited by the level of the river, which in turn is limited by sea level. Variations in humidity would change the position of the point of disappearance, and damper epochs would produce rejuvenation.

The actual laccolith is rarely ideal, but usually consists of several different intrusions, not necessarily circular in outline, into strata not originally horizontal, the whole more or less disturbed by faulting. The Ortiz mountains are abnormal in all these respects. It is no part of the present paper to describe them, but only to point out the generalities of this process as exemplified in them.

If it is possible for a plain to be cut at high altitude in the case of a small and isolated laccolith, the question at once arises as to whether some similar process may not

have produced the broad areas of the great plateaus. It is difficult of demonstration, but the impression is very strong that these plains are not peneplains cut at sea level, but that they were produced at their present altitude by some process more or less analogous to the preceding.

Whatever the factors affecting the region as a whole, there seems no manner of doubt that the conoplain of the Ortiz has been produced in some such manner. There is no evidence whatever of the presence of any large lake or sea that could have afforded even a temporary baselevel for the cutting. Nor is there any evidence that the country has been reduced to a lower level than it has at present, since the Miocene. We are forced to the conclusion that the sloping plains surrounding mountain masses were cut at their present altitude, and that diminishing volume was the essential factor in the cutting.

GENETIC AND STRUCTURAL RELATIONS OF THE IGNEOUS ROCKS OF THE LOWER NEPONSET VALLEY, MASSACHUSETTS.*

By W. O. CROSBY, Boston, Mass.

INTRODUCTION.

The Lower Neponset valley, or more specifically, that part of the valley of the Neponset river within the limits of the Boston basin, properly embraces all that part of the Boston basin between the Blue hills, a denuded anticlinal axis dividing the Boston basin from the parallel and overlapping trough of Carboniferous sediments known as the Norfolk basin, and the broad band of conglomerate extending westward from Savin hill on Dorchester bay through Dorchester, Roxbury, West Roxbury, Brookline and Newton into Wellesley and Needham. This great belt of con-

* This paper is an advance presentation, in outline, of a portion of Part iv of the author's detailed and systematic study of the Geology of the Boston Basin in course of publication in the series of Occasional Papers of the Boston Society of Natural History. For the petrographic distinctions in this field the author is indebted to Dr. Florence Bascom, whose preliminary observations on the volcanics only have been published (Bull. Geol. Soc. America, vol. 11, 115-126), and whose more complete and elaborate work on both the volcanics and plutonics awaits publication in connection with the forthcoming Part iv of the Boston Basin series.

glomerate, some three miles in normal breadth, is, structurally, one simple, flat-topped and somewhat unsymmetrical anticline, the central and dominant arch of the Boston basin (the Shawmut anticline), separated from the Blue hills or southern highlands by the Lower Neponset valley, and from the northern highlands by the Lower Charles valley, each of these main lateral valleys exhibiting, in the general view, a synclinal structure, with slate as the prevailing surface formation, but being, withal, as complex in geological structure as the central ridge or water-parting is simple. As thus defined, the Lower Neponset valley is, west of Boston harbor, a rectangular area some three miles wide and eight to ten miles long, including, on the mainland, small portions of the towns of Canton and Dedham, the whole of Hyde Park, the northern half of Milton and Quincy and the southern half of West Roxbury and Dorchester. It is an area of great topographic as well as geologic complexity, and although, in general, low lying, includes, in Bellevue hill, the highest land within the Boston basin. The district here included in the Neponset valley is not now wholly drained by the Neponset river, this study naturally following geologic, more closely than topographic or hyprographic, boundaries.

The Lower Neponset valley is essentially an epitome of the entire basin, since it also consists of a central anticline of conglomerate bordered on either side by a well-defined slate syncline. The southern syncline, extending through Milton and Quincy, widens rapidly eastward, a somewhat open and composite trough, while the northern syncline, extending through West Roxbury and Dorchester, is a relatively deep and narrow isocline.

The immediate valley of the Neponset is developed in the complex and strongly denuded anticline which thus divides the more southerly of the two main troughs of the Boston basin, and which narrows eastward for the simple reason that the axis pitches or inclines in that direction. The prevailing sedimentary rock of this belt is conglomerate, and the attitude or structure of the conglomerate as a whole is anticlinal. It dips northward along the northern border, passing beneath the slate of the deep and nar-

row Dorchester-West Roxbury syncline; while along the southern border the dip is southerly and the conglomerate passes below the slate of the much broader and composite Quincy-Milton syncline. That the anticline itself is not a simple arch is plainly indicated by the narrow band of slate developed at intervals along the middle of the conglomerate belt and the existence of at least two anticlinal axes, pitching to the east and rising to the west, is further indicated by the fact that toward the west, where erosion has cut through the conglomerate and interbedded flows of basic lava we have exposed, not one, but two, ridges of the underlying crystalline rocks—granite and felsite—representing the floor upon which the conglomerate series was deposited. These two axes are, at most points, of unequal prominence; and in their denuded western extensions the northern axis largely predominates , forming the broad, irregular and broken ridge projecting into the Boston basin from the western highlands of Dedham and Needham and including the granite, quartz porphyry and felsite of the Bellevue Hill district and the Stony Brook reservation, the felsites of the northern part of Hyde Park and the felsites and more basic lavas of the Mattapan district of Dorchester. The minor southern axis is seen in the narrow band of felsite and basic lava, lying mainly south of the Neponset, between Readville and Milton Lower Mills.

Over a part of this area several flows of basic lava or andesite are interstratified with the conglomerate; and during the geological revolution or period of disturbance following the accumulation of these strata and the formerly overlying slate upon the old floor of felsite and granite, they were forced into a gigantic arch from one to nearly three miles broad. This great fold, however, partially broke down in the making, and its collapse was attended by the formation of the minor folds and numerous faults. Subsequent erosion has been so extensive as to remove the entire thickness of slate from the crest of the great anticline, except where it has been carried down most deeply by these minor folds and the faults, occurring now in narrow and discontinuous belts wedged in between the larger masses of conglomerate. The erosion has also been suffi-

cient to cut through the conglomerate series and the interbedded andesite, toward the western end of the arch, where they were most elevated, and thus expose the ancient foundation of felsite and granite.

Probably no phase of this study possesses a greater intrinsic interest than the comparison of the denuded major axis of the Neponset anticline with the Blue Hills complex, which is but the denuded axis of the great anticline separating the Boston and Norfolk basins; and aside from the disparity in area, it is surprising to find how marked is the similarity, except in minor details, and how few are the vital contrasts. In general terms, it may be stated that hardly anything is precisely similar in the two areas and nothing is radically different. In the smaller area as in the larger we have isolated masses of Cambrian strata involved in a complex of post-Cambrian granitic rocks, including the normal granite, the contact zone of fine granite and quartz porphyry, the effusive felsites and the intersecting dikes of diabase of several different systems. The chief contrast is found in the relatively greater abundance in the Neponset complex of the effusive felsites, their more varied character, the great profusion of dikes of felsite in the granites, the more positive identification of some of the principal vents or points of emission of these acid lavas, and the far more complete and clearer exhibition of their relations to the later basic lavas and the inclosing Carboniferous strata.

Among the problems of special interest presented by the Neponset anticline and, apparently, admitting of successful determination, may be mentioned: the detailed relations of the rocks of the basal complex; the mutual relations of the acid and basic lavas—rhyolite (felsite) and andesite; and the relations of both types of volcanics to the

THE BASAL COMPLEX.

The basal complex may best be defined as comprising all of the pre-Carboniferous terranes of this region, both sedimentary and eruptive; or more specifically, as consisting of the Cambrian strata and any other pre-Carboniferous and pregranitic sediments which future investigation may prove to exist here, together with the intersecting and associated igneous rocks of pre-Carboniferous age, includ-

ing the normal granite or main body of the batholite, and its contact zones of diorite, fine granite and quartz porphyry, and the dikes, necks and flows of acid lavas or felsites. As thus defined, the igneous part of the complex is clearly the product of the chemical and textural differentiation of a single great body of magma, embracing, besides the truly plutonic mass or batholite proper, developed, with its variable contact zone, under and in the Cambrian strata, the intrusive and effusive masses evolved, after extensive erosion of the Cambrian cover, from either still unsolidified or remelted deep-seated portions of the batholite.

That the batholite, with the complicating sedimentary and igneous phases, which gives it the character of a true and typical complex, is continuous under all the newer formations of the region and, in its successive phases, essentially contemporaneous throughout, is highly probable; and the variations observed from point to point must, therefore, be regarded either, as actual and due in part to differences in the original magma resulting from the fusion of the pre-Cambrian floor and in large part, also, to the varying thickness and composition of the original Cambrian cover, or as merely apparent and due to the varying depths of pre-Carboniferous and post-Carboniferous erosion, or again, as due to the localization of the intrusive and effusive phenomena which followed the formation of the batholite proper, adding greatly to its structural complexity.

If, with these ideas in mind, we compare more particularly than heretofore the portion of the basal complex rising westward from beneath the Carboniferous sediments of the Neponset valley with the portion exposed, as the result of still more extensive erosion, in the Blue Hills area, we find the more notable differences to be as follows: First, the normal granite of the Neponset valley is prevailingly coarser grained and the ferromagnesian constituent (chiefly hornblende) is more generally and extensively altered (chloritized). Second, the differentiation of the contact zone appears to have been almost wholly textural, and not, to any important extent, chemical, in the Neponset Valley district; and hence we find here only traces of diorite (which is also true of the Blue hills) and nothing closely

corresponding to the basic porphyry and the basic phase of the fine granite of the Blue Hills area. Third, the effusive acid lavas or felsites are, relatively, more abundant and far more varied in the Neponset valley than in the Blue hills. Fourth, the dikes of both acid and basic lavas so characteristic of the basal complex in the Neponset valley are practically or wholly wanting in the Blue hills. Fifth, the necks or actual vents of the effusive acid lavas are far more normally and typically developed in the Neponset valley than in the Blue hills, while the vents of the basic lavas are wholly wanting in the latter area. Sixth, the dikes of diabase, which are found in the eastern and northern parts, and are practically wanting in the main range of the Blue hills, are, in the Neponset valley, characteristic of all parts of the complex as well as of the overlying sediments, no considerable area being free from them. Seventh, erosion has left in the Neponset Valley section of the complex, so far as it is now exposed, only very scanty traces of the original Cambrian cover.

GENERAL HISTORY OF THE COMPLEX.

After what precedes a brief statement will suffice here, the main purpose being a more systematic outline, prefatory to the lithologic and structural details of the complex. As in the Blue Hills area, this area or part of the general batholite of eastern Massachusetts is believed to have been developed beneath a great thickness of Cambrian, and possibly of later, sediments, of which erosion has left only a few highly altered remnants. The thickness of the Cambrian cover was due primarily to extensive sedimentation and secondarily and chiefly to severe or isoclinal plication. The thickening of the super-crust thus determined was sufficient to induce a rise of the isogeotherms, an outflow of the subterranean heat, so marked as to involve softening and final fusion of the sub-crust or floor on which the Cambrian sediments were deposited, developing thus a great body of granitic magma, the corrosive action of which led to the absorption of considerable volumes of the sedimentary cover and gave rise, no doubt, to the normally highly irregular and unconformable contact.

This thickening of the super-crust and consequent great

heat invasion was, doubtless, accompanied by a strong elevation of the surface, permitting extensive erosion, which, in turn, favored the refrigeration of the batholite and the development from the originally homogeneous magma of a vast body of normal granite, with a contact zone consisting, normally, of an inner layer of fine granite and an outer layer of quartz porphyry, both phases of the contact zone being the products mainly of a textural rather than a chemical differentiation of the magma.

Long continued erosion, removing in large part the sedimentary cover of the batholite and probably cutting at some points through its contact zone into the normal granite, was followed by a period of volcanic activity, due possibly to cracking and hydration of the body of the batholite, during which, acid lava, chiefly rhyolite, now existing in a devitrified form as aporhyolite or felsite, was poured out over the eroded surface of the batholite. Several of the volcanic necks or vents of these effusive eruptions have been definitely located and their details of form and structure more or less fully worked out. From the vents or chimneys of these most ancient volcanoes of the Boston basin radial dikes of felsite extend outward into the granitic rocks. As a chronologically distinct record, the complex was now complete; but it was destined to be still further complicated; for these effusive acid eruptions appear to have marked the beginning of the progressive subsidence which inaugurated the deposition of the Carboniferous sediments, beginning with the great conglomerate series; and during the subsidence and clastic sedimentation the effusive eruptions continued, but became of more basic character—grading from rhyolite through trachyte to andesite, which in its present altered form as apoandesite or porphyrite has been heretofore classed as melaphyre, but is now known to be less basic than that type. The andesitic eruptions, from, presumably, greater depths than the source of the acid lavas, are marked by fissurelike necks, by numerous dikes cutting all the older rocks, and especially by successive massive flows or contemporaneous beds intercalated in the conglomerate series.

The volcanic activity finally ceased and continued sub-

sidence introduced the deep water conditions permitting the deposition of the slate series into which the conglomerate series gradually merges upward. The deposition of the slate series was closed, it is supposed, by the Appalachian revolution, during which the Carboniferous sediments were strongly folded and faulted and injected by still more basic magma from, possibly, still greater depths, forming the older or east-west series of diabase dikes, now largely chloritized or typical greenstone. Still later, and probably contemporaneously with the Triassic sedimentation and accompanying igneous activity in the Connecticut valley, were formed the diabase dikes of the newer or north-south series.

With this the rock formations of the Neponset valley were complete, and its later geological history is recorded only in the erosion accomplished during later Mesozoic and Tertiary ages and culminating in the great ice invasion of post-Tertiary or Pleistocene time.

THE CAMBRIAN STRATA.

The existing small remnants, the larger less than a thousand feet long, of the body of Cambrian strata which we suppose to have once formed a continuous cover over the batholite in the Neponset valley, as in other parts of the Boston basin, appear to be confined to the vicinity of the Boston and Hyde Park boundary, in the eastern part of the Stony Brook reservation and the immediately contiguous territory.

The sedimentary rock, of supposed Cambrian age, is all slate, of a uniformly massive, hard and distinctly metamorphic character. The prevailing color is dark gray; but it varies to lighter shades; and very generally the rock is perceptibly veined or clouded with the green of epidote, indicating that the slate was, originally, more or less calcareous, the lime having as an essential phase of the igneous matamorphism, combined with the alumina and silica of the slate to form epidote. This feature allies it with the Lower Cambrian slates of Weymouth, Quincy, Nahant, etc.; but in other respects it bears a striking resemblance to the massive, gray, non-calcareous Middle Cambrian slates, as these are developed on Hayward creek in Braintree and

along the north side of the Blue hills. It exhibits in a good degree the characters of a true hornstone; but it is nowhere of flinty hardness; and the fact that it is never visibly micaceous testifies to the essentially non-alkaline character of the sediment. As a rule, the stratification is hopelessly obscure; but at a few points, which are so distributed as to cover practically the entire group of ledges, it is fairly distinct and entirely unequivocal. The attitude of the bedding is, as usual in the Cambrian of the Boston basin, very constant, with east-west strike and vertical dip.

The essential relation of these sediments to the complex is clearly indicated, not alone by their metamorphic character, but also by typical igneous contacts with the fine granite and quartz porphyry of the contact zone, and irregular dikes or apophyses of the quartz porphyry and more regular dikes of normal felsite.

BODY OF THE BATHOLITE.

Normal Granite—This is a coarsely crystalline aggregate of feldspar and quartz, chiefly, with a small proportion of a dark constituent regarded by Dr. Bascom as chloritized amphibole. The feldspars, according to this authority, include orthoclase, commonly of a pinkish tint due to oxidation, and a lime-bearing albite in which the greenish tint due to epidotization is more or less marked. The analysis shows an acid rock, similar to the normal granite of the Blue hills, but rather more basic and richer in plagioclase, though poorer in the ferro-magnesian constituent.

The outcrops of normal granite are chiefly confined to two rather irregular areas; and the general relations of these to the complex is not central, as might seem most natural, but peripheral. They form, respectively, the northern and southwestern borders of the complex, and converge but, apparently, do not meet, to the northwestward, in the vicinity of Grove and Center streets. The dispositions of the normal granite is such as to suggest at once a general monoclinal or shallow synclinal structure for the complex,—the surface of the normal granite forming a trough the axis of which pitches to the southeast, thus allowing the normal granite to slope southward and northeatsward beneath the contact zone of fine granite and

quartz porphyry and a great thickness of volcanic and sedimentary formations. In the direction of its disappearance the normal granite does not reappear north of the Blue hills; and undoubtedly its disposition, especially in relation to the unaltered sedimentary formations which meet it abruptly on the north, in the West Roxbury district, finds its readiest explanation in a profound displacement along the northern border of the complex, with the downthrow, of course, to the north.

The normal granite is observed at many points to grade upward into the fine granite by which it is bordered; and its surface continuity is frequently interrupted by island-like outliers of the fine granite. These relations are particularly well-exhibited in the broad and massive ledges in the area bounded by Washington, Grove and Center streets and Cottage avenue; and nowhere more favorably than in the vicinity of the large quarry on Cottage avenue, northwest of Washington street.

CONTACT ZONE OF THE BATHOLITE.

Fine Granite—The chief difference between this type and the normal granite is textural. The essential minerals, according to Dr. Bascom, are the same, with the addition of a little microcline and oligoclase to the feldspars. Quartz is reported as more abundant, and the chloritized ferromagnesian constituent as less so, and these distinctions are confirmed by the analysis, which shows higher silica and lower lime, magnesia and iron.

The fine granite belongs to the contact zone and hence overlies the normal granite. It might, therefore, where not removed by erosion, be expected to exhibit a broad areal development, but for the fact that it is, in turn, covered by the quartz porphyry phase of the contact zone. In harmony with this general relation and the shallow synclinal structure of this part of the batholite, the principal area of the fine granite takes the form of an irregular V-shaped belt, 1000 to 3000 feet wide, separating the normal granite on the north and southwest, from the quartz porphyry on the south and northeast, respectively.

As to the thickness of the fine granite, we have no very definite clue. No approximately vertical or continuous

section shows both the normal granite below the fine granite and the quartz porphyry above it. In other words, we have no data for a direct determination of the thickness, save that it must exceed the hight of the highest hill composed wholly of the fine granite, or say 75 feet. It would be readily deducible from the surface breadth if the dip were known. Assuming the dip to be low and inversely proportional to the surface breadth, gives a maximum thickness of a few hundred feet at the most; and 100 to 200 feet may, perhaps, be accepted as a conservative estimate, confirming the conclusions reached in the study of the Blue Hills complex.

The finer granite of the contact zone is, in a fair sense, a bed of passage, since it grades downward into the normal granite and upward into the quartz porphyry; and, normally, its original contacts are nowhere sharply defined, but distinctly blending. It may be noted, however, that, as in the Blue Hills complex, the contact with the normal granite, though blending, is rather abrupt, the complete transition from the one rock to the other being acpassage upward into the quartz porphyry is usually more or, possibly, in extreme cases, a single foot. Although the complished in some exposures in the breadth of a few feet sedimentary rocks.
gradual, all observers must recognize that the fine granite, so far from being all gradation, is chiefly remarkable for the uniformity of texture throughout almost its entire thickness. In fact, it rivals the normal granite in this respect. Locally, and especially near the quartz porphyry, it may pass into a true micrograntie; but it is in general a macrogranite of very homogeneous aspect.* That the fine granite is older than the normal granite and younger than the quartz porphyry, and that these three distinct but blending sedentary zones of the batholite exhibit the structural relations which this sequence requires, will probably not be questioned by those familiar with the field evidence.

* The explanations of the homogeneity of the fine granite and its abrupt yet blending passage into the normal granite suggested in Part III. of the Boston Basin Geology (Occas. Papers, Boston Soc. Nat. History, iv, 354 et seq) are still regarded as valid, and as applicable in this new field.

Quartz Porphyry—This upper or peripheral member of the contact zone has been designated by Dr. Bascom the rhyolitic facies of the granite or more succinctly rhyolite, and more explicitly porphyritic aporhyolite; and for this usage the petrographic characters undoubtedly afford ample warrant. But in order the more sharply to distinguish this essentially plutonic type from the much younger and very dissimilar intrusive and effusive rhyolites, it is proposed to employ here the good descriptive term quartz porphyry. The rock in question is in every instance a true quartz porphyry, with conspicuous phenocrysts of both quartz and feldspar; and, as befits its plutonic origin, it is of remarkably uniform character, matching the granites in this respect; while the clastic, fluidal and spherulitic structures so characteristic of the newer rhyolites are conspicuous by their absence. Such variation as the quartz porphyry shows is due chiefly to its gradation downward into the fine granite; and, as Dr. Bascom has noted, its texture, though aphanitic, allies it with the microgranitic phase of the fine granite, and unlike the younger rhyolites it is rarely truly cryptocrystalline.

In its distribution the quartz porphyry tends to form a V-shaped zone concentric with the fine granite, and separating the underlying fine granite from the overlying effusive rhyolite or felsite. The lower border of the quartz porphyry is rendered rather vague and indefinite at most points by its blending contact with the fine granite. The upper border, on the other hand, where the quartz porphyry meets the effusive rhyolites or felsites is, in the nature of the case, sufficiently definite but highly irregular, since we have here a true erosion unconformity, and two formations, although of closely similar composition and probably derived from the same original magma, are strongly contrasted in structure and widely separated in geological time.

Summary and Comparison—Neglecting unimportant occurrences of diorite and aplite, which may be described, respectively, as relatively basic and relatively acid phases or segregations of the normal granite, and hence as products of a chemical differentiation of the main body or

primal magma of the batholite, we have now considered all of the sedentary or truly plutonic rocks of the batholite. These have been described in the order of superposition, which is, of course, the inverse order of age, since the refrigeration of the batholite must have progressed from the periphery downward or centripetally. That the differentiation of the normal granite and the contact zone, and the further differentiation of the fine granite and quartz porphyry of the contact zone, are not wholly textural is, as noted by Dr. Bascom, clearly shown by analyses, according to which the normal granite is the most basic and the fine granite the most acid, while the quartz porphyry is intermediate in composition, although not so in position. By way of explanation of this chemical relation, Dr. Bascom has suggested that specific gravity and convective currents may have been factors in producing a somewhat more acid peripheral zone to the batholite, while the outer or quartz porphyry border to this zone, following the general law of the order of crystallization (virtually fractional crystallization), by its earlier crystallization left the inner portion of the zone or fine granite more acid than either the quartz porphyry or normal granite. To this explanation may, perhaps, be added the influence of hydration. It appears reasonable to suppose that the primal magma of the batholite, formed under a thick and, necessarily, a hydrated sedimentary cover, and due in part to the absorption of large volumes of this cover, would naturally be more highly hydrated in its superficial than in its deep-seated portions; and since the characteristic elements of an acid magma, including silica and the alkalies, have a stronger affinity for water than have the lime, magnesia and iron oxide characteristic of basic magmas, we have here a cause tending to keep, if not to make, the batholite superficially acid.

That, in comparison with the granitic rocks of other districts, this part of the batholite was formed under a moderate depth of cover, is believed to be indicated by the relatively slight amount of chemical differentiation, by the absence of an original micaceous constituent, and especially by the almost entire absence of a pegmatitic phase in the normal granite. The absence of marked differentiation ex-

tends, in the main, to the earlier intrusions in the batholite, since, with one exception, these are relatively acid, and differ but little in composition from the sedentary members of the batholite.

(Continued in August Number.)

EDITORIAL COMMENT.

ANOTHER METEORITE IN THE SUPREME COURT.

It was decided by the Iowa supreme court, in the case of the Winnebago meteorite, that the meteorite belongs to the owner of the land on which it falls. The tenant found the stone and sold it. The owner brought suit to regain it, and after some years of litigation and delay the court assigned the meteorite to the owner of the land.

The Oregon meteorite case is somewhat different. A metallic mass is admitted by both parties to be of meteoric nature and origin, and as such, according to the Iowa decision, it belongs to the owner of the land on which it fell. The date of its fall however is unknown, and there is evidence tending to show that it was a piece of personal property, separate from the land on which it was found, for many years prior to the date of discovery. The issue and the attendant conditions have been stated as follows by the *Oregon Journal:*

The Oregon City meteorite case was argued before the supreme court yesterday. This is an action brought by the Oregon Iron & Steel company to obtain possession of the metallic meteorite found by Ellis Hughes in November, 1902, on the land of the Oregon Iron & Steel company, about two and a half miles west of Oregon City. The interesting subject of this controversy was found standing upright on a slight knoll. It is of metallic composition, with a dull, rusty surface, its top or flat surface being gouged out into huge potholes or washbowls. As it stood it resembled very much in appearance a mammoth mushroom or inverted bell, in size seven by ten feet across at the top, and four and a half feet thick, its weight being estimated at from three to four tons. It has the specific gravity of soft iron, and in composition is 90 per cent soft iron, 10 per cent nickel, with a trace of cobalt.

Hughes alleged that this was an abandoned Indian relic and

that he was the first white discoverer of it and, believing he had a right to it, he constructed a rude wagon and hauled it to his own home, about three-quarters of a mile distant. He alleged that this meteorite was the property of the Clackamas tribe of Indians (now disbanded and nearly all dead), and that they had a tradition that this magic rock, called by them "Tomanowos," came from the moon, and possessed supernatural influence. He claimed that it was fashioned, erected, maintained and used by them to hold the fluid in which they were wont to dip their arrows before engaging in battle with their Indian foes, and that their young warriors were compelled to journey over there and visit this spirit being on the darkest nights. To substantiate these claims two Indian witnesses were produced, who testified that the above facts were true, according to the legends of their tribes. One of them was a member of the Klickitat tribe of Indians and the other was a Wasco Indian.

Both parties to this case agree that the object is a meteorite, but no proof has been offered by either to show when it arrived on earth. The Oregon Iron & Steel company denies that it is an Indian relic, and claims title to it by virtue of ownership of the land upon which it was found.

It may safely be assumed, probably, that this iron fell on the land where it was found, although there is no proof of it. The Indians who previously visited and worshipped it could not have transported it. If they had ownership of the land they owned the specimen. As they did not remove it, when the land passed from them it would seem that the meteorite went with the land. But the consideration that they had used it as a special object, for a special purpose, foreign to the uses to which land as such is devoted seems to make it an object of personal property. They may have erected it in the position in which it stood, and may have deepened the "potholes" on its upper surface. If a man sculptures a statue from some rock on his land, when he sells the land the statue does not go with the land. If the Clackamas Indians did not own the land, and yet visited and controlled the specimen for a specific use without objection from others, it seems reasonable to assume that the specimen was not an appurtenance of the land and that they had the right to remove it. If they abandoned it, without removal, it seems to belong to that class of Indian relics of which many examples are known and which the finder, rightly or wrongly, becomes the owner.

If the specimen is an Indian relic the ownership thereof

may still be in the owner of the land. He is a trespasser who wilfully passes on to his neighbor's domain; and he is still more a trespasser if he removes, against the owner's protest, any of the property of his neighbor. N. H. W.

Note.—Since the foregoing was written the Oregon supreme court has decided this case, as follows, as published in the Portland Oregonian:

Oregon Iron and Steel Company, respondent, vs. Ellis Hughes, appellant, from Clackamas county, T. A. McBride, judge; affirmed; opinion by Chief Justice Wolverton.

Held, that a meteoric rock is a part of the real property upon which it falls, and evidence that Indians worshipped the rock and dipped their arrows in the water held in its cavities is not sufficient to show that the Indians had dug the rock from the ground and acquired title to it as personal property. The question whether Indian ownership and abandonment is sufficient ground upon which to predicate title in the finder is not decided.

The court did not consider the evidence as to the ownership of the specimen as personal property by the Indians of sufficient force to warrant the reference of the case to a jury for determination. That evidence failing, there was left the bare question as to whether the meteorite belonged to the real estate or to the finder. In that the Oregon court coincided with the Iowa court *in re* Winnebago meteorite. N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Contributions to Devonian Paleontology, 1903. Henry Shaler Williams and Edward M. Kindle. Bull. U. S. Geol. Surv., No. 244, 1905, pp. 1-144.

Bearing of Some New Paleontologic Facts on Nomenclature and Classification of Sedimentary Formations. Henry Shaler Williams, Bull. Geol. Soc. Amer., Vol. 16, March, 1905, pp. 137-150.

Bulletin No. 244 consists of two parts, No. I. listing and discussing "Fossil faunas of the Devonian and Mississippian (Lower Carboniferous) of Virginia, West Virginia and Kentucky," while part II. considers in a similar manner the "Fossil faunas of Devonian sections in central and northern Pennsylvania." A large number of sections in Kentucky, Virginia and West Virginia are

described by Dr. Kindle and accompanied by lists of fossils of the various faunules. The above is followed by a series of short articles, among which may be mentioned "Correlations," "The *Rensselaeria* fauna," "The black shale and its fauna," "The upper Devonian faunas of the middle Appalachians" and a "List of diagnostic Chemung species" by professor Williams. In part II. the descriptions of the sections in central and northern Pennsylvania are mainly by Dr. Kindle; but the formational and faunal correlation is considered much more fully than in the preceding part by both Kindle and Williams.

These two papers have recently been reviewed by professor Schuchert* who considered critically the lower Devonian, or the Helderbergian and Oriskanian series. It appears that similar notes concerning the middle and upper Devonian, to which this review will be largely restricted, might be of value.

Professor Schuchert seems inclined to question the identification of *Anoplotheca acutiplicata* from the black shale near Covington and Hot Springs, Virginia. The writer considers that the identification is probably correct, for the same species occurs near the base of the black shale or Marcellus member of the Romney formation in western Maryland. The Maryland specimens were examined by Dr. John M. Clarke so that no question can be raised regarding their specific identity. From the occurrence of the above species and *Anoplia* associated with others which are "regarded as confined to the Marcellus shale of New York" professor Williams concludes "that the black shale was deposited in a thick mass in the Appalachian trough before the fauna of the Onondaga (Corniferous) formation was extinct." In connection with the above it is well to remember that the Onondaga fauna entered New York from the west and, generally, is supposed to have reached no farther south than northeastern Pennsylvania. Dr. Clarke has shown that "early Marcellus deposits in eastern New York were * * * contemporaneous with late Onondaga deposits in western New York."†

On page 45 of the Bulletin professor Williams speaks of the Romney formation as though it were composed entirely of black shale and this idea is expressed by him more distinctly in the second paper under consideration. The term Romney formation was first published by Mr. Darton in 1892 in this journal and was applied to the rocks in the vicinity of Romney, a town scarcely 15 miles south of the Potomac river in Hampshire county in the northern part of West Virginia. It is located within the Potomac basin and there is very slight change in the lithology or fauna of the deposits in western Maryland to which this name has subsequently been applied. The writer has shown that both on lithological and faunal grounds the Romney formation of northern West Virginia and western Maryland may be divided into two members. The lower one is composed principally of fissile black shale, weathering

* Am. Jour. Sci., 4th Ser., Vol xix, June, 1905, pp. 460-462.
† N. Y. State Museum, Bull. 25, 1905, p. 668.

to a brownish or buff color, together with some bands of dark-colored thin limestone, with a total thickness of about 500 feet. The limestones contain *Agoniatites expansus* (Vanuxem) which is so characteristic of a thin limestone in the lower part of the Marcellus shale in New York that its generic name has been given to it, while the black shales contain numerous specimens of *Liorhynchus limitare* (Vanuxem) and some other species which are regarded as characteristic of the New York Marcellus shale. In a general way this member corresponds with the Marcellus shale of New York with which it has been correlated. The upper member is composed of bluish or bluish-gray shales and sandstones with an approximate thickness of 1,100 feet. This member contains numerous specimens of characteristic Hamilton species of New York and frequently the entire 16 species which professor Williams has previously listed as the "dominant species of the Hamilton formation of eastern New York and Pennsylvania." Evidence indicates that the deposits of the Romney formation in Maryland apparently closed at about the same geological time as the Hamilton beds of New York, and in a general way this member has been correlated with the Hamilton beds of New York. It is not intended to state that the limits of the Romney formation in northern West Virginia and Maryland are *exactly* contemporaneous with the limits of the Erian series of New York; but there is a striking similarity in most details and it is believed that there is no serious error in this general correlation.

The deposits, called Romney shale, which professor Williams has studied in the field, their fossils in the laboratory, and discussed in Bulletin No. 244 are located in southern Virginia and eastern Kentucky. These collections later were supplemented by others made by Dr. Kindle in Kentucky, Virginia and southern West Virginia. It appears, however, that the locality farthest north from which collections were made is 110 miles or more to the southwest of Romney and, apparently, the nearest outcrops of the so-called Romney shale which professor Williams studied in the field are 220 miles or farther to the southwest of that town. It is well known that there is a rapid thinning and marked lithologic change in the Devonian deposits as they are followed from the Potomac basin to the southwest. Professor Williams' own statement "that in the correlation of local formations the same species of fossils alone (when so much as 50 miles of distance separates their stations) can not be relied on for establishing more than a general homotaxial relation of the formations compared"* would suggest caution in correlating with the Romney formation the deposits of Bland county in southwestern Virginia, 220 miles to the southwest. The statement of professor Williams that "the rocks belonging to the part of the column called Romney, in central and southern Virginia, contain chiefly the faunas found in New York in the Marcellus, Genesee, and Nunda ('Portage') with only traces of the Ham-

* Bul. Geol. Soc. Amer., vol. 16, p. 147.

ilton fauna near their base"† is probably true for the region which he studied but is incorrect for the Potomac basin in which the typical outcrops of the Romney formation occur. As we have shown above, the Romney formation in its standard region contains in its lower member essentially the fauna of the Marcellus shale and in its upper member that of the Hamilton beds of New York. It is not until in the succeeding or Jennings formation that the Genesee, Naples or Portage, Ithaca and Chemung faunas are found.

Probably that portion of part II. of most general interest is the discussion and correlation of sections in Northumberland and Columbia counties of central Pennsylvania which had been adopted as standard ones by the state survey in the interpretation of the geology of that part of the state. Perhaps the most important one is the Catawissa section on the Susquehanna river which was very carefully studied by Dr. Kindle in the field and the correlation reviewed by professor Williams. Dr. Kindle shows that the calcareous shales in this section which were correlated with the Tully limestone by the Pennsylvania survey contain a Hamilton fauna, "not one of the characteristic Tully forms appearing." Dr. Kindle, however, considered that the zone "occupies the stratigraphical position of the Tully limestone of New York" while professor Williams stated that it and the two subjacent zones contain "the normal fauna of the Hamilton formation." The writer showed in 1894 that the calcareous shale in Pike and Monroe counties in northeastern Pennsylvania, which the state survey correlated with the Tully limestone of New York is succeeded by some 200 feet of very fossiliferous shales containing a characteristic Hamilton fauna which he referred to the Hamilton formation.* The investigations of Dr. Kindle clearly show, however, that the calcareous shales of central Pennsylvania correlated with the Tully limestone of New York by the Pennsylvania Survey occur at a higher stratigraphic horizon than those of northeastern Pennsylvania as was inferred and published by the writer in 1894.‡ The succeeding 225 feet of bluish-black shales are correlated, on account of lithological similarity, with the Genesee shale and rather more than 25 feet above their top appears the first faunule of the Nunda (Portage) formation. Professor Williams states that the name Nunda formation has been adopted to designate what has heretofore been called the Portage or Nunda group. Two hundred feet above the top of the Genesee shale is a faunule containing *Spirifer pennatus var posterus* which is considered as the first appearance of the Ithaca fauna that then continues through about 1,400 feet of deposits to almost the base of the lowest red shales. Dr. Kindle states that no characteristic Chemung forms appear in these deposits and professor Williams concludes that "Faunally the evidence of the Chemung formation

†Ibid, p. 143.

*Bul. U. S. Geol. Surv., No. 120, pp., 71-73.

‡ Ibid., p. 73.

must be looked for in the still higher strata." The last deposits considered were correlated with the Chemung formation by the Pennsylvania survey in the upper portion of which they reported the characteristic Chemung species *Spirifer disjunctus*. From the lowest reported horizon of this species Dr. Kindle carefully searched every remaining foot of the so-called Chemung deposits without finding a single specimen of *Spirifer disjunctus*. This is in perfect harmony with the writer's experience in northeastern Pennsylvania where he failed to find this species which was reported in rocks of so-called Chemung age.* This detailed work of Kindle and Williams confirms the writer's correlation in 1894 of the so-called Chemung of northeastern Pennsylvania with the *Paracyclas lirata* fauna of the Portage of eastern New York† which later he demonstrated belonged in the Ithaca formation.‡ It is interesting, however, to remember that farther to the southwest in western Maryland the higher Devonian faunas contain numerous specimens of *Spirifer disjunctus* associated with some of the other species which professor Williams lists as diagnostic of the Chemung. C. S. P.

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CORRESPONDENCE.

ESTIMATION OF THE SILICA IN THE BEDFORD LIMESTONE —The specimen used in this work was obtained from a quarry near Bedford, Indiana, and it is known locally as the Bedford limestone. It is a light-colored rock, fine grained in texture, and is widely used and favorably regarded as a building material.

The amount of residue insoluble in hydrochloric acid which proved to be mainly silica was determined by three different methods as follows:

Method 1.

A grain of the fine powder was placed in a small beaker covered with a watch glass. Dilute hydrochloric acid was added and the contents of the beaker gently heated to boiling. After standing a short time, the undissolved portion was filtered off and the weight determined.

Method 2.

A grain of the powder was placed in a porcelain evaporaing

dish, and while covered with a watch glass, dilute hydrochloric acid was added. It was left on the water bath until effervescence ceased, the accumulations on the watch glass were rinsed off, and the evaporation continued until crystals began to appear. Then as the evaporation went forward, the substance was stirred with a glass rod until a fine dry powder resulted. This was moistened with concentrated hydrochloric acid and left on the water bath for a few moments. Dilute hydrochloric acid and water were added and after sanding a short time, the insoluble residue was filtered off, dried in the air bath, and its weight determined. The insoluble residue was obtained three different times by each of the two methods, varying the weight of the original amount taken. The results were as follows:

Method 1.

(a)	With one gram substance	0.54	per cent.
(b)	" three grams "	0.56	" "
(c)	" ten " "	0.55	" "

Method 2.

(a)	With one gram substance	0.65	per cent.
(b)	" three grams "	0.55	" "
(c)	" ten " "	0.55	" "

To determine further the nature of the residue, whether it was all silica, or wholly or partly a silicate, it was treated in the platinum crucible with a few drops dilute sulphuric acid, and the crucible was nearly filled with a dilute solution of hydrofluoric acid. It was evaporated on the water bath and the excess of sulphuric acid removed with the free flame.

Residue in Crucible obtained by method 1:

(a)	One gram substance	0.13	per cent.
(b)	Three " "	0.12	" "
(c)	Ten " "	0.14	" "

Residue in Crucible obtained by method 2:

(a)	One gram substance	0.13	per cent.
(b)	Three " "	0.12	" "
(c)	Ten " "	0.11	" "

A blank test was made using sulphuric and hydrofluoric acid in the crucible and evaporating to dryness. No residue was obtained.

The residue in the crucible was determined and found to be

Aluminum and iron sulphate	0.08 %
Calcium sulphate	0.058 %
Magnesium sulphate	0.00
	0.138%

Method 3. To compare the insoluble residue obtained by fusion with alkaline carbonate with the amount obtained by the foregoing methods.

A gram of the fine rock powder was thoroughly mixed in the

platinum crucible with seven grams of anhydrous sodium carbonate. The sodium carbonate used was a good quality of Merck's manufacture. It was further purified by dissolving a quantity in water and filtering. This after fractional crystallization seemed to be entirely free from silica. The covered crucible was heated for fifteen minutes with a Bunsen flame, then with a blast lamp to complete fusion. The cooled mass was transferred to a porcelain evaporating dish and dissolved in dilute hydrochloric acid. Evaporation was continued on the water bath until crystals began to appear. It was then stirred with a glass rod until a fine dry powder was obtained. It was treated with hydrochloric acid as in method 2 before described. The insoluble residue obtained by this method amounted to 0.53%. This treated with sulphuric and hydrofluoric acids left a residue of 0.16%. The results are fairly concordant with those obtained by methods 1 and 2, but on account of the difficulty of getting pure sodium carbonate, and the length of time and the labor necessary to obtain the result, this process is not to be commended with rocks of this character. Indeed method 1 is greatly to be preferred, whenever circumstances permit, on account of its simplicity, and the shortness of time required.

During the course of this work our attention was called to the estimation of silica as outlined by Treadwell* in his excellent treatise on quantitative analysis. After removing the insoluble residue according to method 2, it is stated that "as much as 5 per cent of the total amount (of silica) may remain in the filtrate. In order to remove this the filtrate from the first precipitate is once more evaporated to dryness on the water bath and kept on the hot water bath for one or two hours or more." It is then filtered after treatment with hydrochloric acid and water in the usual manner.

Several determinations were made in which the suggestions of Treadwell were strictly carried out. One gram, five grams and ten grams of substance were used. In no case was even a trace of residue obtained by the second treatment. The experiment was varied by using a specimen of argillaceous limestone that contained 18 per cent of silica. A second portion of residue could not be obtained from this specimen.

A complete analysis of the Bedford limestone resulted as follows:

$Ca\ Co^3$	93.55%
$Mg\ Co^3$	5.42%
$Si\ O^2$	0.55%
$Fe^2\ O^3$ and $Al^2\ O^3$	0.50%
	100.02%

The condition of the iron was tested by placing three grams of the powdered rock in a flask of 12 c c capacity, fitted with a bulb

* Treadwell-Hall's Quantitative analysis, page 384.

tube and Bunsen valve. The material was dissolved in a small quantity of dilute hydrochloric acid. A few drops of the solution quickly withdrawn and placed on a porcelain tile in contact with a solution of potassium ferricyanide showed a slight tinge of blue. A few drops of a solution of potassium sulpho cyanate were then quickly introduced into the flask when a red color was produced. The portion of the iron soluble in hydrochloric acid is therefore of both the ferrous and ferric forms. No attempt was made to determine each quantitatively on account of the small amount.

The writer acknowledges his indebtedness to Alys Boies Carson for making the experiments of this investigation.

NICHOLAS KNIGHT.

Chemical Laboratory, Cornell College,
July 4, 1905.

PERSONAL AND SCIENTIFIC NEWS.

PROF. W. W. MILLS has been appointed state geologist of Michigan to succeed Prof. A. C. Lane.

DR. O. C. FARRINGTON has recently returned, from a long trip, to the Field Columbian Museum.

MR. W H. HARVEY of Eveleth, Minnesota has been appointed inspector of mines, with headquarters at Eveleth.

DR JOHN M. CLARKE, Director of Science and State Geologist of New York, as well as one of the editors of this journal, has been seriously ill with appendicitis.

MR. GEORGE F. LAMB, a graduate of Ohio university and later a graduate student in geology at Ohio State university, has been elected professor of Biology and Geology in Mount Union college at Alliance, Ohio.

THE "MINING WORLD" of Chicago has recently been purchased by a new stock company. The editorial staff has been strengthened and enlarged, under the direction of Mr. D. T. Day.

PROF. J. VOLNEY LEWIS of Rutger's college will devote the summer to a special investigation of the petrography of the Newark (Triassic) traps of New Jersey and their associated copper ores for the state geological survey.

DR. M W. TWITCHELL, a graduate of Columbian university, Washington, D. C., and of Johns Hopkins university, Baltimore, Md., has been elected to fill the chair of geology in South Carolina college at Columbia, S. C.

MR. ERNEST C. BROWN, publisher of "Progressive Age," is preparing to publish a complete list of the engineers of

America. He has listed already over two thousand and desires information concerning five or six thousand others.

WARREN UPHAM contributes a paper of eighteen pages, entitled "Geological History of the Great Lakes and Niagara Falls," to the July number of The International Quarterly.

DAVID T. DAY of the U. S. Geological Survey has recently made a visit to the Yellowstone Park. He is now in charge of the concentration of black sands carried on by the survey at the Portland exposition, where he also holds the position of honorary chief of the mines department.

MR G. K GILBERT has given to the Department of Geology of Denison university upwards of 1,000 volumes of literature, consisting of U. S. G. S. reports, state reports, reprints, proceedings, and other valuable books. This gift is especially appreciated after having lost their library in the burning of their Science Hall.

THE POSITION OF THE LATE ALBERT A. WRIGHT of Oberlin college has been filled by the election of Maynard M. Metcalf, professor of Biology in the Woman's college of Baltimore, as professor of Zoölogy and Mr. E. B. Branson of Kansas university as instructor in Geology. Dr. Metcalf was granted a two years' leave of absence and the work for the ensuing year will be conducted by Dr. Lynds Jones, associate professor of Zoölogy and Mr. Branson.

THE SET OF CHARTS illustrating the origin of certain metallic ores, prepared by C. R. Van Hise, C. K. Leith and W. N. Smith and exhibited at the St. Louis Exposition, has been reproduced in Vandyke prints for limited distribution, in response to requests for copies. The prints are four in number, iron, copper, gold and silver, and lead and zinc, each about 24 by 50 inches. A charge of 75c each is made to cover cost. Orders may be sent to C. K. Leith, Madison, Wis.

PROF C. H. HITCHCOCK, of Dartmouth college, will spend the months of July and August in the Hawaiian Islands, to visit again their principal volcanoes, all of which he has ascended during his numerous former explorations of these islands. His observations this summer are for revision and completion of a treatise on volcanoes, and especially on their very exceptional characters in the Hawaiian group.

DR. GEORGE D. HUBBARD, instructor in geology and physical geography in Cornell university has been elected assistant professor of Geology in Ohio State university. The other members of the Geological department are Charles S. Prosser, professor of Geology and John A. Bownocker, professor of Inorganic Geology. In recent years

the department has grown very rapidly and during the last four years the number of students has nearly trebled. During the present summer session the instruction in geology is given by Dr. Aug. F. Foerste of Dayton.

"IT WAS STATED IN THE ISSUE OF SCIENCE for April 21, that the New Mexico legislature had appropriated $6,000 for a state geological survey, to be spent under the direction of the New Mexico school of mines at Socorro. We are informed that the only reference to such a survey occurs in the general appropriation bill and is as follows: 'For publication U. S. Geological Survey reports, to be expended under the direction of the Socorro School of Mines, or so much thereof as may be necessary, $2,500.'"—*Science.*

A similar misstatement was published in the GEOLOGIST for April (p. 262).

THE DELAYED ANNUAL REPORT of the Geological Survey of Michigan for 1903 is out. It consists of 342 pages and contains report of the state geologist and included papers. Among the noteworthy articles are those on the soils and vegetation of Roscommon and Crawford counties by B. E. Livingston, and notes on the waters both of the Upper and Lower Peninsulas. There are articles on the theory of copper deposition and the Keewenawan lodes. The report is sent gratis on payment of forwarding charges (13 cents) to teachers for professional use, editors for review and to libraries according to the rules of the Board whose office is at Lansing, Michigan.

THE LATE LEGISLATURE OF ILLINOIS established a state geological survey, putting it under the immediate direction of the trustees of the state university, located at Champaign, but with an advisory board consisting of the governor, the president of the university and one other to be appointed by the governor. The annual appropriation is twenty-five thousand dollars.

In addition to the above the university is to have a school of ceramics, supported by an appropriation of five thousand dollars per year. This, however, will have no connection with the survey except such as common interest dictates.—*Rolfe.*

CONGRESS OF APPLIED GEOLOGY. An international congress of applied geology was called to meet at Liege from 25 June to 1 July, 1905. It took place in connection with the Universal Exposition of Liege, and of the International Congress of mines, metallurgy, mechanics and applied geology, of the last of which it seems to be an offspring. The president and the secretary of the Committee of organization are respectively Max Lohest and René D' Andrimont, both of Liege. Amongst the organizing members

are named the following: Ch. Barrois, P. F. Chalon, De Launay, H. Domage, E. Dubois, J. Gosselet, H. Höfer, K. Keilhack, F. Laur, H. Louis, M. Lugeon, H. Potonié, Schulz-Briesen, F. Villain and numerous Belgian geologists.

THE SCIENTIFIC WORLD will be specially interested to learn that Dr. G. F. Wright, is about to make an expedition to southern Russia and the north end of the Red sea, to complete the investigations begun by him in 1900 and 1901, the object of which was to determine the physiographic changes which have taken place in comparatively recent times in the regions earliest occupied by man, and to ascertain the influence these have had upon the history of the human race.

This expedition is made possible by a special fund presented him as president of the Records of the Past Exploration Society for this particular work. Full reports of his investigations will appear in Records of the Past during the autumn and winter.

During his trip he will receive mail, in care of the American Consulate, at the following points:—Aug. 12, York, England; Aug. 25, Copenhagen, Denmark; Sept. 8, Moscow, Russia; Sept. 15, Vladikavkaz, Russia; Sept. 25, Sevastopol, Russia; Oct. 5, Constantinople, Turkey in Europe; Oct. 15, Beirut, Syria; Oct. 25, Jerusalem, Palestine; Nov. 5, Cairo, Egypt; Nov. 13, Athens, Greece; Nov. 20, Naples, Italy; Dec. 1, Rome, Italy; Dec. 20, Paris, France; Jan. 1, London, England.

BULLETIN NO. 60, OF THE BUREAU OF FORESTRY being a "Report on an Examination of a Forest Tract in Western North Carolina," by Franklin W. Reed, will soon be ready for distribution.

This report contains a comprehensive and detailed description of the forest on about 16,000 acres in the mountains of western North Carolina, which is to be lumbered so that its value as a summer resort shall not be impaired. This tract is typical of many others in the southern mountains, where undeveloped resources afford an opportunity for the practice of forestry or conservative lumbering. The conditions described in this bulletin furnish a concrete example of what such land will yield when placed in the care of a forester, who will look after its landscape features while cutting the merchantable timber. Tables of growth and yield are provided, logging and pleasure roads located, and a system of fire protection outlined.

The bulletin is illustrated with a topographic map and six plates. Application for this bulletin should be made to The Forester, U. S. Department of Agriculture, Washington, D. C.

The Technolexicon of the Society of German Engineers (short report on the state of work June, 1905). In the compilation of this universal technical dictionary for translation purposes (in the languages English, German, and French), that was commenced in 1901, about 2000 firms and individual collaborators at home and abroad are assisting at present.

Up to now 2,700,000 word-cards have been collected. To these will be added the hundred thousands of cards that will result from the working-out of the original contributions not yet taken in hand. The contributions have been called in since Easter, 1904, and most of them have already come in (up to June, 1905: 1480).

The editor-in-chief will be pleased to give any further information wanted. Address: Technolexicon, Dr. Hubert Jansen, Berlin (NW. 7), Dorotheenstrasse 49.

A Special Summer Meeting of the American Anthropological Association will be held in San Francisco, California, on August 29, 30 and 31. After the meeting there will be an excursion to Portland, Oregon, to visit the Lewis & Clark Exposition. Here an informal meeting will be held at which addresses will be made.

The meeting in San Francisco will be held under the auspices of a local committee. This committee will arrange for excursions and entertainments. The headquarters of the Association will be the Department of Anthropology of the university of California at the Affiliated Colleges, San Francisco.

Since special rates are being given by the transcontinental railroads to Portland via San Francisco, it is an exceptional opportunity for ethnologists and archæologists to visit the Pacific coast.

Members intending to be present will please notify the secretary of the local committee, Dr. A. L. Kroeber, Affiliated Colleges, San Francisco. Dr. Kroeber will arrange for hotel accommodation and will furnish information relative to the meeting.

The amendments to the constitution proposed at the Philadelphia meeting (see Amer. Anthropologist, 1905, p. 176) and at the council meeting of April 15, 1905, having been approved by the council, will be presented at San Francisco for adoption.

Mr. George Grant MacCurdy, 237 Church street, New Haven, Conn., secretary of the Association, will give information as to special railroad rates. Titles of papers should be sent to him at an early date.

Albert A. Wright.

THE AMERICAN GEOLOGIST
VOL. XXXVI. PLATE III.

The portrait of Prof. Wright, Vol XXXVI, [illegible]inted. The binder will please [illegible]

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. AUGUST, 1905. No 2.

ALBERT ALLEN WRIGHT.

By PROF. G. F. WRIGHT, Oberlin, Ohio.

PORTRAIT—PLATE III.

On the afternoon of Saturday, April 1, 1905, professor Albert Allen Wright was about his usual duties, but upon going to his study upon his wheel was suddenly seized with spasms of pain which, after continuing for twenty-four hours, ended in his death, upon Sunday afternoon. For some years professor Wright had suffered more or less from ill health, for which physicians found it difficult to account. A year of rest upon the Pacific coast in 1900 failed to bring the expected relief, but partial relief was found in a severe course of dieting. The mystery, however, was solved by a post-mortem examination, which showed that, as a result of an illness many years before, there was an adhesion between the stomach, liver, and gall bladder, which suddenly gave way, producing acute peritonitis. Thus closed the earthly career of a most accomplished geologist and naturalist, a broad-minded student of science in general, a successful teacher, an efficient man of practical affairs, and a devout Christian of such delightful personality that he won the regard of every one who came in contact with him.

As so many persons have supposed that professor Wright and I were brothers, it is well to say, at the outset, that we were not, and that our relationship, if any, was so distant that it has not been traced. But twenty-five years of close association with him in college work and much longer general acquaintance had drawn me to him as to a brother, while his judgment in scientific affairs was so sound and unerring that I felt impelled to seek it at every stage of my own work.

Professor Wright was born in Oberlin, Ohio, April 27, 1846, being a son of William Wheeler and Susan Allen Wright, connected, on his father's side, with the family of Orville Wright, and on his mother's with the late professor Frederick Allen of Harvard university. He graduated from Oberlin college in 1865, having served for three months in Company K of the 150th Regiment of the Ohio National Guard, which was called for the defense of Washington in 1864. For two years he taught in the Cleveland institute, when he returned to Oberlin, and, like so many other distinguished geologists, among whom are to be numbered professors J. P. Lesley and Edward Orton, pursued a course of theological studies, two years of which were taken in Union theological seminary, New York City, and the final year in Oberlin seminary, from which he graduated in 1870. For the following two years he filled the chair of mathematics and natural science in Berea college, Kentucky, after which he entered the School of Mines of Columbia college, from which he graduated in 1875. In later years his education was continued in a more general way by numerous extended expeditions into Canada, the Rocky mountains, Florida, and other portions of the Atlantic coast, while the year 1884-85 he spent in traveling in Europe.

On September 21, 1874, he was married to Mary Lyon Bedortha, of Saratoga Springs, N. Y., from which union there is left a daughter, Helen M.; and August 18, 1891, to Mary P. B. Hill, of Flemington, N. J., who with a son survives him.

In 1874 he was called to the chair of geology and natural history in Oberlin college, a position which he filled with complete satisfaction to all for thirty years, to the time of his sudden death. He signalized his connection with Oberlin college by establishing and fostering the laboratory system of study by students in all scientific departments, so that his pupils have shown remarkable facility in their postgraduate studies and in finding entrance to the higher spheres of scientific investigation.

But he accomplished a large amount of work outside of his classroom, as will be seen by the appended list of publications. In 1874 he was engaged upon the second geolo-

gical survey of Ohio to make a report upon the lake ridges of Lorain county. The published results of his work remain the standard source of information concerning that locality. In 1884 he was employed to make the report upon the coal-seams of Holmes county, and in 1893 he was asked to make, for the current volume of the Survey, a report on "The Ventral Armor of Dinichthys," based upon the unique specimens from Lorain county preserved in the Oberlin college museum, in which he demonstrated that what are described by Dr. Newberry as jugulars are really the "companions of his anterior ventrals."

Among the most commendable aspects of professor Wright's scientific work are those which come to light in connection with his practical interest in the affairs of the town and state. Such confidence did his fellow-citizens have in both his attainments and his character that as soon as they contemplated the inauguration of a sewer system and waterworks he was chosen by universal consent to be the leader in formulating plans. After an untold amount of examination of the local conditions, and of study of the subject from every point of view, he presented plans which were accepted, and which, executed under his direction, have secured to Oberlin the model equipment of the state, to which the State Board of Health is constantly referring committees from other localities. All this was accomplished at a minimum of expense to the town. It is also through professor Wright's influence chiefly that the legislature of the State was persuaded to co-operate with the United States geological survey inaugurating a topographical survey of Ohio. His papers, presented to the committees of three different legislatures, and others published broadcast throughout the state, are models both in the statement of the scientific results to be published and of the practical ends to be secured, in order to justify the large appropriations made.

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General Zoology. n. p. n. d. 4 p.

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Optical properties of rock-making minerals n. p. n. d. 8 p.

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Students' collection of fossils. n. p. n. d. 4 p.

The dissection of molgula. n. d. 7 p.

GENETIC AND STRUCTURAL RELATIONS OF THE IGNEOUS ROCKS OF THE LOWER NEPONSET VALLEY, MASSACHUSETTS. [II.]

By W. O. Crosby, Boston, Mass.

PRE-CARBONIFEROUS INTRUSIVES.

The earlier or pre-Carboniferous intrusive rocks of the batholite include the following types: granite porphyry, quartz porpryry, felsite and acid andesite. The first three are acid and agree closely in composition, as stated above, with the sedentary types of the batholite, so that they may fairly be regarded as later extravasations from the deeper parts of the same great body of magma. The fourth type, on the other hand, is of distinctly sub-acid or neutral composition, as a partial analysis accompanying Dr. Bascom's description clearly shows. Furthermore, the dikes of this relatively basic type are, according to the rather meagre but quite satisfactory evidence, older than all of the acid intrusives, suggesting eruption from a source below the normal granite and hence during a time (possibly of marked elevation and erosion) when the batholite proper was congealed throughout its entire thickness.

The acid intrusions, on the contrary, including both dikes and necks, may, in the main at least, as previously indicated, be correlated with the subsidence ushering in the sedimentation of Carboniferous times and accompanied by a rise of the isogeotherms sufficiently marked to reliquefy a portion of the ancient acid magma. This correlation is confirmed by the close agreement in composition of the acid intrusions and the normal granite,—for the unquestionable connection of the acid intrusives (both dikes and necks) with the acid effusives or lavas, which rest unconformably upon the deeply denuded surface of the batholite, shows that in origin the intrusions are separated from the sedentary zones of the batholite by a vast time interval during which the magma must have been mainly solid to have escaped marked chemical differentiation.

Acid Andesite Dikes—This is a rock of distinctly neutral composition, anlyses showing from 60 to 62.8 per cent. of silica; and Dr. Bascom's observations indicate a hornblende-bearing biotite andesite. A single dike only has

been studied in detail; but it is known to represent a more or less extensive series, the acid andesite not having been distinguished heretofore from basic andesite and greenstone diabase. This dike begins in the fine granite on Heron street near Washington street and, with a normal breadth of 20 to 25 feet, has been traced northwesterly, parallel with Cottage avenue, into the normal granite and for o total distance of nearly half a mile. It is clearly cut by typical dikes of quartz porphyry and felsite; and the acid andesite occurs as angular inclusions in a great dike of granite porphyry. These relations give it at once a unique position among the basic intrusives of this area and, so far as known, of the Boston basin, by definitely fixing it, chronologically, between the batholite and all of the acid intrusives. Comparison is suggested at once with the more basic, pre-granitic dikes (diabase) in the Cambrian slates of the Blue Hills.* The latter are the only basic dikes in the Boston basin known to be older than the granitic series of the Complex; and the West Roxbury dike just described is the first relatively basic dike in the Boston basin known to be intermediate in age between the sedentary zones and the acid intrusions of the complex.

Granite Porphyry and Quartz Porphyry Dikes.—In this instance, also, the detailed study has been limited to what is, virtually, one large and complex example; but the general conclusions thus reached are definitely known to be applicable to an extensive series of dikes. The fine granite of Bearberry hill in the northeast part of the Stony Brook reservation is traversed in a general northwest-southeast direction by a vertical dike of quartz porphyry 100 feet wide. The greenish gray, aphanitic groundmass of the porphyry is crowded with conspicuous phenocrysts of feldspar up to one-half, and even three-fourths, of an inch in length, while the more scattering, rounded blebs of quartz are commonly one-fourth to one-half inch in diameter. Altogether it is a striking rock and one readily recognized and traced. The quartz porphyry is densely felsitic near the contacts, which are firmly welded, irregular in detail, and further characterized by occasional inclusions of the fine

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* Occas Papers, B S N H Iv, 388.

granite in the quartz porphyry and minor apophyses of the latter in the former.

On this hill, also, the quartz porphyry dike is cut by a four-foot dike of compact and purple felsite, and gives off an oblique branch 20 feet wide, traceable for a thousand feet, and cut by another felsite dike 10 to 15 feet wide.

The phenocrysts of the branch dike are relatively small and inconspicuous, and comparable in size with those of the contact zone; while this contrast between the main dike and its branch proves that in neither case can the phenocrysts be regarded as antedating the intrusion of the magma. On the other hand, the lithologic resemblance of the branch dike to the quartz porphyry phase of the contact zone must be regarded as a mere coincidence, since we have to do in the one case with the earlier phase of the batholite, and in the other with relatively late intrusions cutting, as we shall see, all of the sedentary zones of the batholite from the normal granite to the quartz porphyry.

Southeastward, the main dike is traceable across the reservation boundary and nearly to the Boston-Hyde park line, where it is seen to cut the quartz porphyry of the contact zone and the enclosed masses of Cambrian slate. In the opposite direction from Bearberry hill, across the drift-floored valley of Turtle pond and beyond Washington street, in the large Cottage avenue quarry in normal granite, capped by fine granite, and exactly where the great dike of quartz porphyry might be expected to reappear, we find instead, and with the same trend, a dike of profusely porphyritic granite porphyry, 30 to 50 feet wide. With aphanitic and firmly welded margins, it cuts, clearly and unmistakably, both the normal and the fine granite; and it is, in turn, cut squarely across by a small dike (2 to 4 feet) of felsite in which the fluxion structure parallel with the irregular walls is beautifully developed. Apparently, there is no reason to doubt that this intrusive granite porphyry which Dr. Bascom regards as essentially identical in composition with the normal granite, is also simply a more crystalline phase of the intrusive quartz porphyry, the two rocks being part of one and the same continuous dike; and facts yet to be noted abundantly confirm this conclusion.

The next outcrop of this dike, where it crosses Heron street, is also granite porphyry; but beyond this the quartz porphyry phase recurs, and the dike, now 75 feet wide, is lithologically indistinguishable from the Bearberry hill section. From this point on, it is near to and approximately parallel with the dike of acid andesite previously described; and the latter is cut by minor dikes or apophyses of quartz porphyry. The outcrops of both dikes are now interrupted by a swamp, beyond which the dike of acid andesite continues unchanged, while the porphyry dike, now 80 feet wide, is once more a typical granite porphyry, apparently repeated by an oblique strike fault and, as previously noted, enclosing angular fragments of the acid andesite. Thus twice in a total distance of a little more than a mile, the quartz porphyry gives way to granite porphyry. In neither case, unfortunately, can the transition be fully traced; and yet we may not reasonably doubt its reality. This remarkable and rhythmic textural variation in the contents of one and the same continuous fissure may, perhaps, be regarded tentatively as finding its most natural explanation in varying original depths of solidification. That is, if we may assume a natural gradation upward in the dike from granite porphyry to quartz porphyry, then a moderate amount of subsequent displacement, or even of unequal erosion, might suffice to give the alternations of texture which the outcrops now show. In this connection it may be noted that in the lowest outcrop of the main dike, at the western base of Bearberry hill, the quartz porphyry is well advanced in the change to granite porphyry. It is a fair corollary of this explanation that the granite porphyry should be found chiefly in the normal granite, and the quartz porphyry in the fine granite. This relation is clearly realized in part; and would, perhaps, be more fully realized, but for the fact that, as we suppose, the batholite suffered strong and unequal erosion before its injection by these acid intrusives.

Felsite Necks.—Besides its abundant occurrence in effusive forms or surface flows, the devitrified rhyolite (aporhyolite) or felsite has an important development in necks and dikes, which are undoubtedly contemporaneous

with the acid effusives; and nowhere, apparently in the Boston basin, are normal effusives more clearly or typically developed. Some of the felsite dikes are large enough to be regarded as the vents of effusive masses; and very probably several of them are deeply denuded necks. The more typical and unequivocal necks, however, are less dike-like in outline and far more diversified in structure, consisting chiefly of clastic lavas—agglomerate and tuff—suggestive of explosive eruptions toward the end of the volcanic activity and following more quiet liquid effusions. Three essentially distinct vents have been more or less fully worked out; and it is considered not improbable that others await recognition in the felsite areas. This appears the more likely in view of the fact that acid lavas of fluidal and autoclastic types, that is, lavas which were stiff enough at the time of their effusion to develop fluxion lines, or even to become brecciated by their own flow, would not spread far from the vents through which they reached the surface. We must recognize also the extreme probability that some vents are still concealed by their own sluggish effusions or by later sediments. The three vents referred to as more or less fully identified are near the heart of the complex and bordered either wholly or in part by the sedentary zones of the batholite, including the normal granite, fine granite and quartz porphyry; and evidence is not wanting that they are, in each case, located on important displacements, one indication of this relation being elongation in a definite direction, the outlines being distinctly lenticular.

The West Roxbury Neck.—This neck is the most clearly exposed in outline and in structural detail, and probably the largest, as it is certainly the most indubitable of the series. It occupies approximately the irregular triangular area bounded by Grove, Center, Stimson and Washington streets in West Roxbury, near the Dedham line.

It is elongated in a general northwest-southeast direction, the extreme dimensions being approximtaely 1200 by 3500 feet. The major axis coincides in position and trend with the common boundary of the fine granite and the western area of normal granite, the evidence being quite conclusive that this line marks an important displacement.

The sharp definition of this neck, with its continuous rim of granite, is, of course, chiefly due to the fact that erosion has removed the last vestige of the effusive felsite which we must assume to have once covered its site and a wide area of the enclosing granites.

Not to classify this sharply defined body of acid lavas as a true neck or vent would seem to necessitate regarding it as a depressed fault block or graben, a remnant of a once widely extended volcanic sheet covering the granites which has escaped erosion through the accident of displacement. But the varied and prevailingly clastic character of the lavas and the general structure of the mass are, at least, highly suggestive of a vent, and force the conclusion that there must be a vent somewhere in this part of the complex. Although, omitting intersecting dikes of felsite, andesite and diabase, the neck is almost wholly composed of effusive types of felsite; it is yet, quite independently of the dikes, highly diversified in composition and structure—a constantly varying complex or chaos of fragmental, fluidal and compact or structureless lavas. The clastic phase, ranging from the finest tuff to the coarsest breccia or agglomerate, largely predominates and gives character to the whole, leaving little room to doubt that the later eruptions, at least, from this vent were in part explosive. Although varying greatly in azimuth and inclination, and usually much contorted, the normal attitude of the flow structure of the felsite is parallel with the axial plane of the neck, or, in the peripheral portions, with the proximate wall of granite. The interest of the peripheral phenomena culminates in the southeastern extremity of the neck, where it is continued in the shattered zone of granite in which it had its origin as a complex of granite and felsite, the granite being cut in all directions by irregular branching and coalescing dikes of the felsite, which is brecciated, banded, compact or porphyritic by turns and encloses many large and small angular fragments of the granite.

While we need not doubt that the fragmental lavas are, in the main, true pyroclastics, the product of explosive eruptions, it is very probable that they are in part autoclastics, or breccias resulting from the continued movement

of the magma after it began to stiffen and solidify. The distinction of these two types in the field must usually be a puzzling matter, so much depending on the nature of the matrix or ground mass; but it is assumed here that local homogeneity of composition (not of texture) and absence of granitic debris are characters belonging more normally to the autoclastics. In considering the distinction and probable relative abundance of the pyroclastic and autoclastic lavas, both of which are undoubtedly prominent features of this neck, and may also be designated, respectively, agglomerate and breccia, we may properly take account of the possibility that the eruptions were subaqueous, at least in part, and note the cracking and shattering of the lava that would follow its sudden quenching. It is doubtful, however, if much of the breccia has the crackled character, with accurately fitting fragments, which this explanation would require. Nevertheless, the presence of water is plainly suggested by the rather distinct stratification of some of the finer tuffs, such as may be observed in the central part of the neck especially.

Attention is thus directed to one of the most interesting and puzzling features of the neck. This is a very compact gray, slaty-looking rock, irregular masses of which are enclosed in the more normal or unquestionable agglomerate and also in the fluidal felsites and occur only in the western central portion of the neck, all the outcrops being included within an area about one thousand feet long in a north-south direction and perhaps half as wide. This material, which may be as distinctly, evenly and finely, or as obscurely, stratified as any slate, was at first mistaken for an older slate enclosed in the volcanics. But further study of the field relations showed that it must be contemporaneous and essentially a tuff or consolidated ash. As noted by Dr. Bascom, this conclusion is confirmed by both the microscopic and the chemical analyses. The combined alkalies are far higher than for a normal slate and agree closely with those of the felsites. These masses range in extent from a few inches to many feet. They are sometimes ill-defined, cloud-like patches in the lavas; but more commonly they are sharply outlined and the contacts with

the felsite are unquestionably igneous, being firmly welded and the sediment well baked for a breadth of one to several inches. Even closely adjacent masses do not usually agree in dip and strike; but the relations are what might be expected in the case of a bed or beds of imperfectly consolidated ash disturbed by later eruptions, largely of an explosive character. The close relation of the consolidated ash or slaty tuff to the felsite agglomerate is clearly indicated in some instances by the intercalation of visibly clastic layers. Finally, we may regard the ash as the finest product of an explosive eruption which was in some sense subaqueous, closely followed by eruptions which were only in part of an explosive character, yielding, besides the true agglomerates, compact, fluidal and autoclastic felsites intersecting and enclosing, alike, the agglomerate and the ash.

Accepting the West Roxbury neck as a true volcanic vent, as apparently we must, it may be assumed to have originated in a more or less complex and branching fault fissure; and the local widening of such a fissured zone to the present breadth of the neck when it finally became the locus of vulcanism would be a natural consequence of the explosive action of which we have such ample evidence. In other words, we need not assume that the granite was melted away, or forced out en masse, Pelée fashion; but it is sufficient to assume a splintering and shattering of the granite walls under the influence of shock and heat. The resulting granite debris would be borne upward by the constantly increasing volume of viscous lava made possible by the widening of the vent, and finally discharged, largely through the agency of violent explosions. This explanation, the essence of which is a gradual crumbling and exfoliation, accompanied by cracking and rending of the granite walls of the primordial fault fissure, accounts for the general diffusion of granitic detritus through the clastic lavas, as well as for larger, isolated masses of granite which now add to the diversity of the neck.

The Hyde Park Neck.—This large and composite neck occupies a more central position than the West Roxbury neck in relation to the complex; and presents some other distinguishing features. It is, probably, best regarded, in

detail, as two necks developed on fissures, approximately parallel with the major axis of the West Roxbury neck; but converging irregularly northwestward, near the Cambrian outliers; and the united axes might be regarded as continued in the great dike of quartz and granite porphyry. Where most widely separated and most distinctly developed as necks, these fissures are clearly compensating displacements bounding a depressed area approximately half a mile wide.

The southwestern fissure, designated the Bold Knob neck, shows a wall of the massive quartz porphyry of the contact zone bordered on the northeast by several hundred feet in breadth of coarse felsite agglomerate, the felsitic matrix of which is packed with large, angular fragments of both felsite and quartz porphyry. Northeastward, or away from the wall of quartz porphyry, the agglomerate becomes rapidly finer and shades off into fluidal, spherulitic and other obviously effusive forms of felsite. Similarly the northeastern fissure, known as the Grew's Woods neck, shows an immense mass of exceptionally coarse agglomerate sharply limited on the northeast by normal granite. The agglomerate has a maximum breadth of nearly a thousand feet, passing gradually, as before, into the effusive felsites, which are continuous over the area intervening between the two bodies of agglomerate. Not only has the effusive felsite discharged by flow and explosion from these fissures overspread the depressed area which they bound; but from this expanding area, as from a cornucopia, the felsite flows have spread eastward over a large part of Hyde Park and into Dorchester and Milton. Unlike the West Roxbury neck, and on account of the general eastward inclination of the geological structure of the district, erosion has not cut deeply enough to remove entirely the effusions of this most eastern of the recognized felsite necks.

Felsite Stocks.—Besides the large and essentially indubitable necks of acid lava described in the preceding pages, we must, as previously noted, recognize several more or less probable stocks or plugs of felsite in the sedentary zones of the batholite. These masses, which may, perhaps,

best be regarded as more deeply denuded as well as smaller necks, are intermediate, in size at least, between the undoubted necks and the normal felsite dikes. They are related to the necks in form and to the dikes in lithologic character, lacking entirely the clastic and fluxion characters and the general structural heterogeneity of the necks. One difficulty in regarding them as dikes is that they do not appear to occupy dynamic fissures, being chimney-like rather than dike-like in form. The clearest examples are roughly circular or elliptical plugs 200 to 300 feet in diameter, isolated in, and enclosing numerous fragments of, the normal granite. The rock, although felsitic in general aspect, is, perhaps, better described as a dense; non-porphyritic microgranite. It is essentially homogeneous and structureless, except for an indistinct peripheral zone of true felsite, in part fluidal.

Felsite Dikes.—In the general view the entire area of the complex appears to be traversed by dikes of felsite. They are, however, especially characteristic of the sedentary zones of the batholite and the felsite necks, and are observed less commonly in the effusive felsites. In spite of the fact that they sometimes cut both the felsite necks and flows, the dikes, as a whole, are undoubtedly best regarded as essentially contemporaneous with the acid volcanics, and we may fairly suppose that in some instances they have formed effective vents. We have seen that they intersect the great dikes of quartz porphyry and granite porphyry; but here, again, an important difference of age is not, apparently, a necessary inference. The relation of the felsite dikes to the necks is in some cases distinctly radial; but a broader view shows that with few exceptions they tend to be normal to the major axes of the felsite necks and the fracture zones in which the necks have been developed. The prevailing trend, therefore, is northeasterly and southwesterly.

In the extension of the axial shear zone of the West Roxbury neck, the felsite forms a plexus of irregular intrusions, which branch and coalesce in a quite remarkable way; while the true dikes represent the filling of comparatively simple and sharply-defined transverse fissures due,

perhaps, to torsional stresses accompanying the shearing.

The felsite dikes range in size up to a hundred feet or more; and they can be traced in some instances for a good fraction of a mile; but the correlation of individual outcrops is often difficult because of marked irregularities of form and trend. As described by Dr. Bascom, the felsite of these dikes is mainly either densely compact or, more commonly, inconspicuously porphyritic. In general, and as might naturally be expected, the larger dikes have porphyritic centers and nonporphyritic or compact borders; while the smaller dikes are often nonporphyritic throughout. With few exceptions, the peripheral portions of the dikes exhibit more or less distinct, and often very marked, fluidal structure parallel with the walls; and the smaller dikes may be characterized by the fluxion lamination through their entire thickness. The large dikes, also, are usually dark red or purple in the middle portion and greenish gray along the borders; while the small dikes are commonly gray across the entire section. It appears probable that the normal original color of the felsite was gray, that it was subsequently reddened by oxidation and later bleached by deoxidation and leaching along the borders. The greenish color of the periphery is, however, according to Dr. Bascom's observations, to be connected, in most cases at least, with a more or less marked epidotization, often followed by hydration and the development of pinite; and not infrequently a border of nearly pure, soft, green pinite has resulted.

PRE-CARBONIFEROUS EFFUSIVES.

Effusive Felsite or Normal Aporehyolite.—The acid effusions of the vents described in the preceding sections, and, doubtless, of other vents still entirely concealed by the effusives, probably constitute for the Neponset valley, a more or less continuous sheet of lava chronologically and stratigraphically intermediate between the denuded surface of the batholite and the Carboniferous sediments and distinctly unconformable in its relations to both. The petrographic and chemical characters of the effusive felsites have been fully described by Dr. Bascom. The original textural variations are most notable, including compact, fluidal, spherulitic, and clastic forms. Although the surface ex-

posures are numerous and instructive, by far the most complete section of the felsites was that afforded temporarily during the construction of the Stony Brook-Neponset tunnel, nearly a mile long, of the High-level sewer. This shows the felsites resting upon both the normal and fine granites at points remote from the nearest surface exposures of these rocks. The flow structure of the felsites, originally horizontal, is now everywhere highly inclined and chiefly vertical, showing that the plication of the Carboniferous sediments was shared by their volcanic floor. As to the original or normal thickness of the acid effusives of the Neponset valley, we have no reliable data; but it was quite certainly to be measured by hundreds and probably not by thousands of feet.

CARBONIFEROUS VOLCANICS.

The volcanic rocks definitely known to be contemporaneous with the Carboniferous conglomerate of the Neponset valley include a moderately acid type—trachyte, and a moderately basic type—andesite. The andesite largely predominates; but the trachyte is, in the main at least, the older and may, perhaps, be regarded as in some sense a transition type between the felsite and andesite.

Apotrachyte.—As described by Dr. Bascom, this is a coarsely and profusely porphyritic rock of highly feldspathic composition, with albite as the predominating feldspar. Dr. Bascom shows that the chemical analysis of this rock confirms its classification as a soda-trachyte in which diopside must have been an original constituent; or, having regard for its present altered condition, it may be more precisely defined as a soda-apotrachyte. This rock has been recognized as forming one small flow conformably interbedded with the conglomerates of the Central Avenue district in Milton, and a probable vent, in part of agglomeratic structure, on the New England railroad north of River street, Hyde Park. The latter occurrence was intersected and more fully exposed by the Stony Brook-Neponset tunnel.

Apoandesite.—This important volcanic is described by Dr. Bascom as an aphanitic rock of dark purplish and greenish tints in which the original constituents are mainly altered to calcite, chlorite, epidote, quartz and other second-

ary species. The microstructure is commonly trachytic and inconspicuously fluidal and porphyritic; and the effusive phases are often amygdaloidal or clastic. The distinguishing feature, chemically, as for the trachyte, is found in the high percentage of soda; and the extensive mineralogic alteration, without obliteration of original structures, makes this, therefore, a normal soda apoandesite.

In areal extent and structural value the Carboniferous andesite is comparable with the pre-Carboniferous felsite; and like the felsite, it is found in the three general modes of occurrence—necks, dikes and flows. The bedded lavas, both acid and basic, of the Neponset valley are believed to be exclusively contemporaneous.

The andesite dikes are very numerous; and they are found in all parts of the complex—cutting the successive zones of the batholite and its cover of acid lava (felsite), and cutting also the acid dikes of various types, including the porphyry dikes, and the necks, stocks and dikes of felsite. In distribution, trend, form and size they are comparable with the felsite dikes; and the profusion of the basic dikes clearly indicates a very general and extensive fissuring of the subcrust during the subsidence which permitted the deposition of the Carboniferous conglomerate.

It is not improbable that some of the andesite dikes have formed effective vents. But of unequivocal or normal necks there are no indications in the sedentary zones of the batholite or in the vicinity of the felsite necks; but they are to be found farther east, in the effusive felsites, the clearest examples occurring on either side of the Neponset, in the Mattapan district of Dorchester and the Columbine district of Milton. These vents are decidedly elongated or fissure-like; but they are readily distinguished from the andesite dikes by even greater irregularity of outline and especially by the heterogeneity of structure and the prevalence of coarsely clastic or agglomeratic lava. The evidence is quite as clear as for the dikes that the andesite is younger than the effusive felsites.

The andesite flows, like the dikes, are chiefly aphanitic, but embrace, also, amygdaloidal and scoriaceous forms; and in the western part of the field, especially, bedded tuff and

agglomerate, the product, probably, of explosive submarine eruptions, are prominently developed. The contemporaneous relation of the effusive andesite and the conglomerate is especially clear for these fragmental varieties; but hardly less so for the regularly interbedded flows in the Central avenue and other parts of the field. The transverse sections of individual flows are, in some instances, very instructive, showing a normal gradation upward from densely aphanitic to amygdaloidal and scoriaceous forms of lava.

DIABASE DIKES.

As previously intimated, the diabase dikes of this area, as of the Boston basin generally, are referable to two distinct series—distinct in age, trend and lithologic character. We may properly emphasize the chronologic distinction, as of greatest geologic significance, by designating these two series, provisionally, the Carboniferous and the Triassic. Evidently, the diabase dikes are not related in origin or composition to any of the other igneous rocks of the district; and in size, regularity and continuity the two systems are essentially similar and normal.

Carboniferous Diabase Dikes - The normal trend of the numerous dikes of this series is approximately east-west; and they rarely vary more than thirty degrees from the normal. Although commonly approximately vertical, they are more likely than the Triassic dikes to exhibit a distinct hade, especially in the sedimentary terranes, the manifest tendency being to conform with the strike joints of the enclosing formation. In other words, these are longitudinal dikes, traversing a series of unsymmetric folds, and sympathizing in attitude with the tension planes of the flexures, having been developed during a period of folding and strike or thrust faulting. In the dikes of this series transverse columnar jointing is rarely distinctly developed. Lithologically they are rather fine-grained greenstones, the original or normal constituents having suffered extensive chloritization and epidotization, in consequence of which the diabase is somewhat immune to kaolinization and to be reckoned among the more resistant rocks of the region.

Triassic Diabase Dikes—The rather infrequent dikes of this series adhere very closely to a north-south trend and

vertical attitude, a hade of even a few degrees being very unusual. Their relation to the general geological structure of the region is distinctly transverse; and, evidently, they date from a period of gravity faulting without folding, such as the Triassic is known to have been. Transverse columnar jointing is commonly well developed; the greenstone alteration is wanting; and the rock yields readily to kaolinization, the tendency to pass by spheroidal weathering to a rusty brown earth being a marked feature of this diabase.

STRATIGRAPHY OF THE EASTERN OUTCROP OF THE KANSAS PERMIAN.*

By J. W. Beede and E. H. Sellards.

PLATES IV-V.

According to Prosser† and Frech‡, the Wreford limestone may be considered the base of the Kansas Permian. The writers' studies are at present confirmatory to this view. From a geographic standpoint this is a most fortunate occurrence as this limestone forms one of the most striking and persistent escarpments in Kansas. It is the most easily mapped formation in the state with the possible exception of the Florence flint, sixty feet above it. The northern two-thirds of the outcrop has already been worked out and discussed in greater or less detail, and is fairly well known, but this can hardly be said of the southern third. The object of the present paper is to give a generalized map of the outcrop, so far as determined, and to furnish an idea of the stratigraphy, throughout the length of the strike in Kansas—a distance of over 200 miles while the extent of the outcrop is several times as great.

NATURE OF THE OUTCROP.

In the region north of the Kansas river the escarpment formed by the Wreford limestone is frequently fainter than that of the Florence flint and Fort Riley limestone. This is true of most of the Blue river region north of Garrison. The Cottonwood limestone escarpment is subordinated in

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† Jour. Geol., x, pp. 709, 710, 721-724, 1902.

‡ Lethaea Palaeozoica, II, Lief. 2, p. 379, &c, 1899.

the northern third of its outcrop where the Wreford limestone and Florence flint appear in the same bluffs, as in some localities in the Blue river region. However its outcrop is always strongly marked when it is found at considerable altitudes above drainage level or well removed from the flints, as at Manhattan, Frankfort, Alma, etc., except when deeply drift covered as near Summerfield.

In the central region, from the Kansas river south to the vicinity of Reece, the Wreford limestone is best developed and forms a very strong escarpment with the Florence flint forming another just above and west of it. Throughout this region as far south as Bazaar, Chase Co., the Cottonwood limestone escarpment retains its sharp outline and whitish appearance. For the entire distance from the Nebraska line the Cottonwood limestone retains its striking peculiarities which are so distinct that even an amateur would not overlook it. The same may be said of the Florena shale lying upon it. South of the latitude of Bazaar both these layers lose their distinctive characters and cease to be of great importance as horizon markers. Whether or not they extend across the southern part of the state as distinct strata can only be determined by carefully tracing them the entire distance. In the southern region, except, perhaps the southern fourth of it, the Wreford limestone escarpment becomes somewhat accentuated, where it actually reaches the crest of the ridge. This is due as much to the drainage as to the relative importance of the stratum which is really thinner here than it is farther north. At Beaumont and Grand Summit it has been removed from the top of the escarpment. At the former place it occurs at the front of the ridge some distance north and south of the railroad but falls back to the middle of the town and is lower in altitude than the railroad grade at the crest of the escarpment on account of the westerly dip of the rocks. This is more strikingly the case at Grand Summit where the Wreford limestone and some ninety feet of underlying rocks have been removed along the railroad as far west as Grouse creek, west of Cambridge. About two miles north of Grand Summit it appears in the top of the escarpment and also forms a high ridge west of the town,

as will be noted later. South of this region local structures come to be of some importance and the stratigraphy has not been worked out in detail. Just east of Dexter it may be seen dipping sharply into the ground to the eastward while the general dip is to the west.

As far south as Reece the Florence flint reaches nearly to the edge of the escarpment forming a second prominent bench. South of this it becomes, frequently, less distinct—except in the region of Burden, and comes in in the backslope toward the Walnut river forming a second escarpment. It is impossible to locate the Cottonwood limestone with certainty here by its lithologic or other characters. All the limestones of any considerable importance are excellently shown in the numerous cuts and exposures but none of them possess the typical appearance of the Cottonwood. The writers are of the opinion that it is continuous with changed lithologic characters throughout this region, but this is by no means certain. It has never been traced to the southern limit of Kansas and "into Oklahoma" by any Kansas geologist.* The statements of Keyes were probably based on Haworth's reconnaissance map published in the first and second reports of the Kansas survey,† which was probably based on Adams' section from Galena to Wellington.‡ If the Cottonwood limestone extends this far south the map mentioned is not much in error as to its general location. On this map the Cottonwood limestone is marked as the upper limit of the Coal Measures and the rocks above are indicated as Permian in accordance with Prosser's earlier opinion.§

The outcrop of the Florence flint and Fort Riley limestone closely parallels the outcrop of the Wreford limestone across the state and could be represented in a general way by a line close to the line on the accompanying map, but lying just west of it. The same would be true of the Cottonwood limestone as far south, or a little farther, than the latitude of Emporia but lying just east of the Wreford limestone. In such places as Manhattan, Frankfort, and Mill

* Keyes, Amer. Geol. xxiii, pp. 308 and 311.
† Univ. Geol. Surv. Kans., I, pl. xxi, 1896; II, pl. xlviii, 1897.
‡ Op. Cit., I. pp. 16-20, 1896.
§ For the original classification and the references to the literature see, Jour. Geol., III, pp. 682-705, 764-800 and especially chart p. 800, 1895: For revised classification see Ibid. x, pp. 703-737, 1902.

creek, in Wabaunsee county, there would be some error in the latter statement, but in general it would be true.

DETAILS OF STRATIGRAPHY.

In order to give a clear idea of the stratigraphy of this horizon throughout its great extent of outcrop it will be necessary to discuss each of the several associated formations and give detailed sections of well distributed exposures.

As already stated the escarpment of the "Flint hills" (formed by the Wreford limestone, Florence flint and Fort Riley limestone) is so marked a feature that it may be traced across the state without difficulty. Quite as striking still is the great uniformity of the formations associated with the escarpment.

Northern province: In 1858 Henry Englemann passed over this region and briefly discussed the rocks, probably in the vicinity of Frankfort and Marrett.* In 1881 Broadhead published a paper on the "Geology of the Central Branch railroad"† giving sections, particularly at Frankfort. These papers are discussed by one of the writers in the Kans. Univ. Quart., IX, pp. 191-202. In 1895 Knerr ran a section over the same route.‡

The Nebraska area has been pretty thoroughly discussed by Knight.§ The writers have been over the Blue Springs (=Wymore), Nebraska area and studied his sections in a general way. According to Knight's section the thickness of the Florence flint in the bluffs opposite Blue Springs, numbers 5 to 7 of his section, is 19 feet 2 inches, with 13 feet, numbers 8 and 9, of the Fort Riley limestone exposed above it. At the Crusher quarry, near the B. and M. R. R.—U. P. junction south of Blue Springs we measured the section of the Florence flint, finding it to be 19 feet 6 inches with a four foot layer of limestone beneath. Including this limestone, which was not included in the flint in Knight's section, the total thickness would be 23 feet 6 inches. This lower layer is somewhat fossiliferous. Just north of the junction beneath the U. P. bridge over the little

* Simpson, Expl. Exped. Gt. Basin, Utah, p. 254, 1859.
† Kans. City Rev. Sci. and Ind., V, p. 119 et seq.
‡ Univ. Geol. Surv. Kans., I, pp. 140-144, 1896.
§ Jour. Geol., vii, pp. 357-374.

creek the Wreford limestone is exposed. The interval between this outcrop and the base of the Florence flint, in the Crusher quarry is 61 feet, barometrically. This interval represents the thickness of the Matfield formation at this locality, with,.perhaps, some of the upper part of the Wreford limestone.

(For the description and definition of the formational terms used in this paper see the two papers of Prosser previously cited and Folio 109, U. S. Geol. Surv. Atlas. It is also necessary to call attention to Adams' paper, Bull. 211 U. S. Geol. Surv., 1903, in which these formations were discussed and given the names proposed by Prosser in the latter of the two papers referred to which appeared about 10 months prior to Adams' paper. Consequently Adams' statements concerning the Elmdale, Eskridge, Matfield and Doyle formations, pp. 54-59, that "It has not heretofore received a distinct name" etc. etc. are in error. More lamentably so because from his own statement to me he was thoroughly cognizant of Prosser's paper for months before his paper was published.—Beede.)

Owing to an anticlinal structure north of the Kansas line the Wreford limestone appears at the B. and M. R. R. junction as just mentioned and is somewhat fossiliferous. The section beneath the U. P. bridge is as follows:

4.	Chert, a fourteen inch layer	1 ft.	2 inches
3.	Limestone, irregular and rather thin bedded	3 "	0 "
2.	Shales, hard buff	3 "	0 "
1.	Shales, blue, extending to the creek bed	2 "	0 "
	Total	9 ft.	2 inches

Numbers 3 and 4 probably represent the upper part of the Wreford limestone and are somewhat fossiliferous while 1 and 2 are probably interbedded shales with the major part of the limestone below.

At Holmesville (not visited by the writers) a little over 20 feet of limestone, according to Knight's section may be referred to the Wreford, the lower six feet of which is cherty.* The section at the state line was not visited by the writers but according to Knight's section there are 35 feet of Matfield shales, numbers 1 and 2 of his section,† and apparently 15 feet of Florence flint, number 3. However it seems probable that number 4 of his section contains about two feet of cherty limestone belonging to the Flor-

* Op. cit. p. 363.
† Loc. cit. p. 367.

ence flint. Numbers 4 to 7 represent the Fort Riley limestone, of which 33± feet are shown in the section. In Beede's section at Oketo‡ the top of the Matfield is shown in the ravine just north of the depot. The thickness of the Florence flint is given as 17 feet and the total thickness of the overlying Fort Riley limestone is given as 37 feet.

Passing down the Big Blue river to Marysville we find the same general conditions repeated. In the northern part of the town 11 feet of the top of the Matfield formation followed by 20 feet of the Florence flint and 26 feet of the Fort Riley limestone are exposed, as shown in the following section:

MARYSVILLE SECTION.

10.	Limestone, thin bedded, disintegrated	2+	ft. 0	inches
9.	Limestone, brownish with fragments of pelecypods	2	" 6	"
8.	Limestone, thin bedded, light colored grading into shale	3	" 9	"
7.	Limestone, cellular, with iron streaks and stem-like marks	3	" 9	"
6.	Limestone, cellular	5	" 0	"
5.	Marls and clayey shales with brachiopods and bryozoans	9	" 0	"
4.	Limestones with layers of chert and chert concretions, including a two foot layer of soft limestone below the chert. Aviculipinna at the top of the flint	20	" 0	"
3.	Shale, soft, gray and fossilferous	0	" 6	"
2.	Limestone	2	" 6	"
1.	Shales, red and blue, carbonaceous in places, with plants	8	" 0	"
	Total	57	ft. 0	inches

Numbers 1-3 belong to the Matfield formation, number 4 is the Florence flint and 5-10 are classed with the Fort Riley limestone.

Number 3 is a quite fossiliferous calcareous shale as is number 5. The latter seems to be more nearly related to the Fort Riley limestone lithologically, that is, it seems to grade into the limestone laterally more than into the flint, and is classed with it. Bryozoa and Brachiopods are the dominant fossils of this layer. The individual layers of the

‡ Paper cited above.

Fort Riley limestone show a tendency to pinch out, or to be lenticular as is shown in the Marysville and Oketa quarries but it has no effect on the thickness of the stratum as a whole.

There is an excellent exposure of the lower Permian rocks, ranging from the upper part of the Wreford well into the Fort Riley limestone, on the west side of the Big Blue river three miles south of Marysville where the bottom road crosses a bridge over a little creek. The section begins at the river level and passes up the creek beneath the bridge to the top of the high, bare-faced bluff above the bridge. At this point the Wreford limestone passes beneath the Big Blue river, causing a slight fall.

SECTION AT BRIDGE ACROSS CREEK THREE MILES SOUTH OF MARYSVILLE ON THE WEST SIDE OF THE BIG BLUE RIVER.

28.	Limestone	5+	ft.	0	inches
27.	Covered	10	"	0	"
26.	Limestone, shaly	3	"	0	"
25.	Limestone with fossils and a little chert	2	"	0	"
24.	Shales, yellow, with fossils	1	"	6	"
23.	Limestone with 3 to 4 layers of concretionary chert	3	"	4	"
22.	Shale, calcareous, or marl	0	"	9	"
21.	Limestone with thin chert layer below and 4 inch layer in upper part	2	"	0	"
20.	Limestone with 7 layers of concretionary chert	5	"	6	"
19.	Limestone with 4 layers of concretionary chert	4	"	0	"
18.	Shales, fossiliferous, = layer below flint at Marysville	0	"	6	"
17.	Limestone, argillaceous	3	"	0	"
16.	Shales, red and green with sandstone layer	14	"	0	"
15.	Sandstone, soft red	1	"	3	"
14.	Shales, clayey, blue, olive and green	19	"	0	"
13.	Limestone, blue	1	"	0	"
12.	Shales, blue clayey	3	"	0	"
11.	Talus, by barometer	25	"	0	"
10.	Shales, green, showing in creek bank	1	"	6	"
9.	Covered, creek bed	3	"	0	"
8.	Limestone, gray clayey	2	"	0	"
7.	Limestone, very compact with smooth fracture, solid geodes	1	"	0	"

6.	Limestone, very dark blue argillaceous.......	5	"	0	"
5.	Limestone, 6 inches to 1 foot, with fragments of fossils beneath bridge	1	"	0	"
4.	Chert, 5 inches to..........................	0	"	6	"
3.	Limestone, blue with fragments of fossils.....	0	"	6	"
2.	Chert	0	"	4	"
1.	Limestone, thin layers below high water at the mouth of the creek. Farther out in the river a layer of chert may be seen at low water	?	"	?	"
	Total	118	"	8	"

Numbers 1 to 8 represent the upper part of the Wreford limestone, a total of over 10 feet 4 inches. The section covered by the high water in the river at the time of our visit should be added to this in estimating its thickness at this exposure. Numbers 9 to 16 are the layers of the Matfield formation which has an aggregate thickness here of 67 feet 9 inches. Numbers 17 to 23 represent the Florence flint with a thickness of 19 feet. There are 21 feet 6 inches of the Fort Riley limestone, numbers 24 to 28, exposed at the top of the section.

On the side of the hill west of Marysville the Florence flint and Fort Riley limestone have a combined thickness of about 60 feet. Resting on the limestone are 20 feet of red, blue, green and yellow shales followed by a comparatively thin limestone. The remainder of the hill is covered to the top, a distance of about 40 feet. The base of the Winfield limestone should be found here but no traces of it were noticed.

In eastern Marshall county, near Beattie, the Cottonwood limestone is eight feet thick, the lower part being impure. At this locality the Florena shales are only two feet thick.* Above this are exposed ten feet of argillaceous limestones and indurated calcareous shales of the lower part of the Neosho member of the Garrison formation. Going west along the railroad from the outcrop of the Cottonwood limestone to what appears to* be the Wreford limestone shown in the cut near milepost 102 on the Grand Island R. R. the barometer showed a rise

* Numbers 1 to 3 are the Cottonwood limestone, and 4 is the Florena shale. Kans. Univ. Quart., ix, p. 195.

* Kans. Univ. Quart., ix, p. 196.

of 70 feet. Allowing for the probable dip would give the Garrison formation a thickness of 110 feet in this vicinity.

Since it was necessary to select another term than the "Cottonwood shales" for the shales immediately above the Cottonwood limestone the term "Florena shale" was used† because of the extensive quarries in the Cotonwood limestone at Florena which show the shale admirably, rich in its typical fauna, though somewhat diminished in thickness when compared with the Cottonwood Falls region. The section at the Florena quarries is as follows:

FLORENA QUARRY SECTION.

5. Limestone, extremely thin bedded, and shale	3	ft.	0 inches
4. Limestone	2	"	0 "
3. Shale, calcareous with abundant fossils, the Florena	3	"	8 "
2. Limestone, nearly white with small Fusulinæ	2	"	2 "
1. Limestone, the upper third with many Fusulinæ	5	"	6 "
Total	16	ft.	4 inches

Numbers 1 and 2 are the Cottonwood limestone and number three is the Florena shale. Numbers 4 and 5 are the base of the Neosho member of the Garrison formation. The Florena shales thicken to the southward, from two feet at Beattie to 3 feet 8 inches at Florena. This thickening continues to the Cottonwood river where they reach a thickness of 6 feet.

Southward from Florena, in the vicinity of Garrison, the Cottonwood limestone passes down to about, or a little below, the level of the river. Here the Garrison formation, Wreford limestone, Matfield formation, Florence flint and Fort Riley limestone all take part in forming the picturesque bluffs of the Big Blue river. It may have been from the inspiration of this place that Cragin named the lower Permian rocks of Kansas the "Big Blue Series."* There are 82 or more feet of the Garrison formation exposed in the bluffs by the town. The Wreford limestone has a

†Prosser, Revised classification of the upper Paleozoic formations of Kansas, Jour Geol., x, p. 712 and the table of formations opposite page 718. See note on p. 737, where the "Cottonwood limestone" is retained and "Alma limestone" is dropped.

* Colorado College Studies, vi, p. 5, 1896.

thickness of somewhere from 30 to 45 feet (can not be well determined from the face of the bluff), and the Matfield formation has a thickness of about 70 feet. The Florence flint is about 20 or 25 feet thick and the Fort Riley limestone is about 40 feet.

According to our figures the total thickness of the section in the hill at Garrison is 300 feet. One of the writers was informed that the bluff had been measured by transit and level and found to be 268 feet above the town. Our section includes the higher hills to the north of the flag pole, which, probably, were not included in the measurement just referred to.

About a quarter of a mile west of the Garrison junction Beede gives a section of fifteen feet of the base of the Wreford limestone.* A mile farther west he gives another section beginning somewhat above the Wreford limestone and continuing into the Fort Riley limestone.† Number 1 of this section should read 25 feet instead of 20 feet, making the total thickness of the section 98 feet, divided as follows: Matfield formation 51 feet, Florence flint 22+ feet, with 21 feet of the Fort Riley limestone exposed.

This general survey gives an idea of the stratigraphy of the lower Permian and associated rocks north of the Kansas river. These rocks from Manhattan and Junction City southward to the Cottonwood river have been made familiar to the geological public by Prosser and Hay and only some of the salient points will be mentioned to bring them clearly to the reader's mind.

Central Province.—At Manhattan, Prosser gives the thickness of the Cotonwood limestone as five feet,* and at Alma five and one-half feet. West of Manhattan, along the Kansas river the higher formations appear. Prosser† reviews the sections of Meek and Hayden, Swallow, and Hay. According to Meek and Hayden's estimate the Garrison formation had a thickness of 109 feet; according to Swallow the thickness is from 124 to 153 feet, while Prosser found it to be 122 feet. Meek and Hayden give the thickness of the Wreford limestone as 40 feet; according to Swal-

* Op. cit. p. 199.
† Loc. cit. p. 201.
* Bull. Geol. Soc. Amer., vi. pp. 33, 37.
† Op. cit. p. 47 et seq.

"Flint Hills Escarpment" at Garrison, Kansas, Valley of the Big Blue river. The conspicuous limestone on the crest of the bluff is Fort Riley limestone. The limestone showing by the tree on the face of the bluff just to the left of the center of the picture is the Wreford limestone.

low it is 36 to 50 feet and Hay‡ finds it to be 25 feet thick on the Fort Riley military reservation. The Matfield formation is represented on the Fort Riley military reservation by 52 feet of shales and limestones.§ Meek and Hayden give it a thickness of 67 feet in the Kansas river region. Hay assigns a thickness of 25 to 30 feet to the Florence flint, number 9 of his section, and 52 to 62 feet to the Fort Riley limestone, while Meek and Hayden estimated the thickness of the Florence flint at 38 feet.

It is probable that Mr. Hill's footnote referring to number 14 of Hay's section to the Marion formation (now called the Winfield limestone) is correct. At the time of our visit the high hill where Hay probably obtained the uppermost members of his section was the target for daily artillery practice and the writers scrupulously refrained from the study of its rocks and fossils.

On account of the condition of the exposure at the time of our visit and its accessibility a section of the rocks at Junction City is given below. The Wreford limestone in this section is hidden, occupying a terrace just above the mill. The section is located on the south side of the Smoky Hill river a little south of east of Junction City, beginning at the water level at the mill by the wagon bridge and following the wagon road to the top of the hill. This section is diagonal to the east end of Hay's section* and crosses it in a southeasterly direction.

SECTION AT THE MILL BY THE BRIDGE OVER THE SMOKY HILL RIVER A LITTLE SOUTH OF EAST OF JUNCTION CITY.

38.	Covered to the place where the road crosses the hill, limestone exposures on higher ground on either side of road	15	ft.	0	inches
37.	Limestone, shaly	15	"	0	"
36.	Limestone, buffish brown with small pelecypods	2+	"	0	"
35.	Limestone, shaly, 11 to	12	"	0	"
34.	Limestone, light colored	1	"	0	"
33.	Limestone, Fort Riley "main ledge"	5	"	0	"
32.	Limestone, rough, with "car-links" on top	3	"	6	"
31.	Shales, calcareous, yellow	9	"	0	"

‡ Bull. U. S. Geol. Surv., 137, p. 17.
§ Hay, Loc. cit. p. 17.
* Loc. cit. pl. ii.

30.	Flint and limestone, Florence flint	22	"	6	"
29.	Limestone, shaly; and shales	3	"	6	"
28.	Shales, red, green, and olive	7	"	6	"
27.	Shales, calcareous	1	"	0	"
26.	Shales, red and yellow	9	"	0	"
25.	Limestone	0	"	6	"
24.	Shales	4	"	6	"
23.	Limestone and shales	2	"	6	"
22.	Shales	2	"	0	"
21.	Shales, indurated; and limestone	1	"	6	"
20.	Shales, light colored	4	"	0	"
19.	Limestone, 0 to	0	"	4	"
18.	Shales, light reddish	4	"	6	"
17.	Limestone, slabby 6 inch to	1	"	0	"
16.	Shales, reddish	2	"	0	"
15.	Limestone, massive	1	"	0	"
14.	Covered	3	"	0	"
13.	Flint and limestone	3+	"	0	"
12.	Covered	45	"	0	"
11.	Shales, maroon and green	4	"	0	"
10.	Limestones with green shale partings	2	"	6	"
9.	Shales, green	2+	"	0	"
8.	Limestone, gray	0	"	9	"
7.	Shales, bright green	1	"	0	"
6.	Limestone	2	"	0	"
5.	Clay and shales, lower ½ cross bedded and blocky	9	"	0	"
4.	Conglomerate with calcareous cement, fish teeth, 1 inch to	0	"	2	"
3.	Clay, with smooth joints	0	"	9	"
2.	Shales, blue, green and maroon, indurated	4	"	0	"
1.	Shales, reddish, lower part covered, high water level	3	"	0	"
	Total	210	ft.	0	inches

This gives 29 feet of the Garrison formation in this exposure with probably 23 feet to be added as Hay's section gives 25 feet as the thickness of the Wreford at this locality. It is very probable that number 13 of our section is the top of the Wreford. The thickness of the Matfield formation here is 48 feet (52 feet according to Hay). The Florence flint is 22½ feet (given as 25 to 30 feet by Hay). If number 29 were added to the Florence flint it would cor-

respond to Hay's section, but would reduce the thickness of the Matfield formation an equal amount. Numbers 31 to 37 of our section are Fort Riley limestone and show a thickness of at least 47½ feet of it exposed, with the probability that much of Number 38 should be added.

The region from Junction City to Cottonwood Falls has been well summarized by Prosser.* Taking the region as a whole he ascribes a thickness of 6 feet to the Cottonwood limestone, 140 to 145 feet to the Garrison formation, 40 feet to the Wreford limestone, 60 to 70 feet to the Matfield formation, 20 feet to the Florence flint, 40 feet to the Fort Riley limestone, 60 feet to the Doyle shales and 20 to 25 feet to the Winfield limestone. Detailed sections are given in the folio referred to.

Southern Province.—South of the region represented in the Cottonwood Falls folio changes are to be noted in the appearance of some of the strata under consideration. South of the latitude of Bazaar, Chase Co., the Cottonwood limestone has never been definitely located nor its horizon accurately mapped. Keyes† states, referring to the Cottonwood limestone, that "its geographic range is wide, extending from Nebraska through central Kansas into Oklahoma." Again‡ "The stratum (Cottonwood limestone) has been traced from southeastern Nebraska where it passes beneath the Cretaceous, entirely across Kansas into Oklahoma. It often forms a noticeable topographic feature." The Cottonwood limestone has never been traced across Kansas into Oklahoma unless it was done by Keyes himself. Indeed, as will be shown in the following discussion, it can not be recognized with certainty by any of its characters south of the region just mentioned. Other stratigraphic changes occur in the Garrison, Elmdale and intermediate formations so that the members can not be recognized readily by their lithologic characters and can only be determined by carefully tracing the outcrops south from the known localities. One of the writers endeavored to locate the Cottonwood limestone in the southwest corner of Lyon county and traversed its general horizon to Reece but was unable to locate

* Jour. Geol., iii, p. 773 and some of the preceeding pages. See also Cottonwood Falls Folio, U. S. Geol. Surv. Atlas, number 109.

† Amer. Geol. xxiii, 1899, p. 308.

‡ Loc. cit. p. 311.

it with certainty. At Reece, Beaumont and Grand Summit excellent exposures of all the important limestones of the entire section are shown, but nowhere is a stone with all the characters of the Cottonwood limestone to be found. The fauna of the general horizon is somewhat similar to that of the Florena shales but it is distributed through a fairly wide range of rocks and is nowhere so pronounced as in the northern localities. In short the Cottonwood limestone ceases to be of great value as a horizon marker south of the latitude of Bazaar.

The stratigraphy of this region can best be compared with that farther north by detailed sections. The regions near Reece, Beaumont and Grand Summit furnish excellent exposures of the rocks concerned in the Flint Hills escarpment. North of this region the flints have been so constantly associated with this escarpment that it has led to some errors of observation in its southern prolongation. For this reason the sections near the places just named are given in considerable detail.

SECTION FROM REECE TO SUMMIT SIDING.

70.	Limestone, massive with many chert concretions in layers	15±	ft.	0	inches
69.	Limestone, very cherty, covered with fallen chert	3	"	0	"
68.	Limestone containing 3 or 4 layers of flint. Fusulinas	3	"	6	"
67.	Limestone, shaly	3	"	8	"
66.	Shales, calcareous	0	"	8	"
65.	Limestone, shaly	1	"	0	"
64.	Shales, blue calcareous	2	"	4	"
63.	Limestone, shaly	2	"	0	"
62.	Shales, yellowish and greenish	7	"	0	"
61.	Covered	8	"	0	"
60.	Limestone, hard, massive	3	"	0	"
59.	Shales, fossiliferous	3	"	0	"
58.	Limestone, rotten, and fossiliferous	1	"	0	"
57.	Shales, yellowish, indurated, fossiliferous	9	"	0	"
56.	Limestone, rotten, and calcareous shales	3	"	0	"
55.	Shales, green and yellowish	8	"	6	"
54.	Shales, maroon	8	"	0	"
53.	Shales, bright green	2	"	0	"

52.	Limestone, massive, hard	1	"	9	"
51.	Limestone, shaly	2	"	6	"
50.	Limestone, cherty, probably 3 feet but showing only	2	"	3+	"
49.	Shales, yellow	5±	"	0	"
48.	Shales with plants, fishes and ostracods	0	"	6	"
47.	Limestone, rotten	1	"	8	"
46.	Shales, yellow	2	"	0	"
45.	Limestone	1	"	6	"
44.	Limestone with flint	1	"	2	"
43.	Shaly layer	0	"	4	"
42.	Limestone, massive	5	"	0	"
41.	Limestone with heavy flint layers	4	"	0	"
40.	Shales, yellowish and clayey limestones with fossils	7	"	0	"
39.	Shales, green	4	"	0	"
38.	Shales, maroon	12±	"	0	"
37.	Limestone, slabby	0	"	6	"
36.	Shales, light blue	5	"	0	"
35.	Limestone, shaly	7	"	0	"
34.	Limestone, hard gray	0	"	9	"
33.	Limestone, clayey and rotten, pelecypods. Same as in cut east of the big fill	10	"	0	"
32.	Limestone, shaly and slabby	4	"	6	"
31.	Shales, greenish	3	"	6	"
30.	Limestone, hard blue	0	"	9	"
29.	Shales, light greenish or bluish	8	"	0	"
28.	Clay, soft yellowish, with rotten limestone on top	2	"	6	"
27.	Limestone, shaly and slabby with some shales	10	"	0	"
26.	Limestone	0	"	6	"
25.	Shale	0	"	6	"
24.	Limestone, hard	1	"	0	"
23.	Covered, with two well-marked limestone horizons	70±	"	0	"
22.	Covered, mostly, down to top of Wooster's section; thin limestones and shales	125±	"	0	"
21.	Limestone in four layers, buff, Fusulina	3	"	0	"
20.	Shales, buff	5	"	0	"
19.	Shales, carbonaceous	2	"	0	"
18.	Limestone, buff shaly, with fossils. Fusulina	1	"	6	"
17.	Shale, blue and full of fossils. Fusulina	3	"	4	"
16.	Limestone, buff and cherty containing Fusulina	1	"	9	"
15.	Shades, calcareous	0	"	9	"
14.	Limestone, buff, Fusulina	1	"	0	"
13.	Shales, dark, buff on weathered surface. No fossils	3	"	0	"

12.	Limestone, buff, top full of Fusulina	2	"	0	"
11.	Shale	5±	"	0	"
10.	Limestone	2±	"	0	"
9.	Covered	30	"	0	"
8.	Limestone weathering to a dirty dark gray	1±	"	0	"
7.	Covered	11	"	0	"
6.	Shale, yellow, green and red with rotten limestone near the middle, thin sandstone of 1 inch or 2 inches near top	35	"	0	"
5.	Limestone in thin layers made up of pelecypods	1—	"	0	"
4.	Shales, soft clayey, and weathered slope	33	"	0	"
3.	Limestone, massive brownish, forming fall in creek	1	"	3	"
2.	Shales, green and blue soft clayey	5	"	0	"
1.	Limestone, brown, massive with Productus cora	1	"	6	"
	Total	530	ft.±		inches

Numbers 1 to 3 are in the creek west of the road just northwest of Reece, the remaining lower part of the section (numbers 4 to 9) extends up the bluff from the creek. Numbers 10 to 21 are in the cuts near the spring about 1¾ miles west of Reece on the railroad. This part of the section corresponds to Wooster's section.* Numbers 22 and 23 extend from the top of these cuts to the big fill about 7 miles N. W. of Reece. Numbers 24 to 40 are shown in the cut and stripping by the big fill (which is the same as the big trestle mentioned by Prosser): 40 to 49 are in the fourth cut east of Summit siding; 50 to 56 are in the third cut east of Summit, 57 to 60 in the second and 61 to 70 are in the first cut east of Summit.

Just prior to our visit, the great trestle on the eastern face of the escarpment had been filled, as had the smaller ones between it and the crest of the ridge. In securing the material for the fills, the available soil and loose material had been removed from the right of way in the vicinity of the cuts, leaving ideal exposures from which to make exact sections. These exposures threw light on points which were before obscure. In the light of our sections we make the following summary of formations.

Numbers 1 to 40 are Coal Measures or Pennsylvanian;

* Kans. Univ. Quart., vi, p. 153, footnote.

not being able to recognize the formations with certainty in this lower part of the section it is deemed best not to attempt to draw approximate lines to the formations, though these numbers include the equivalents of the Elmdale, Neva, Eskridge, Cottonwood and Garrison formations and probably some of the formations below. Numbers 41 to 52 are the Wreford limestone, with a thickness of over 27 feet 8 inches. The Matfield formation is represented by at least 58 feet 6 inches of rock, without number 67, which would make it 62 feet 2 inches, (numbers 53 to 67). There is more or less of a question as to whether or not number 67 should be classed with the Matfield. We are inclined to include it with the Florence flint. Numbers 67, or 68, to 70 represent the Florence flint with a thickness of 21 feet 6 inches without number 67 or 25 feet 2 inches with it.

A large amount of plant remains was taken from a cut in the wagon road just east of a small ravine near the top of the escarpment west of Reece. This horizon seemed to be the equivalent of numbers 19 and 20, though this was not determined with certainty. It is probably well down in the Elmdale formation, possibly at its base. Number 48 produced a large number of plant remains, fish and ostracods. The Cottonwood limestone was not located with certainty and as a consequence the thickness of the Garrison formation can not be stated. It seems probable that Prosser's location of the horizon of the Cottonwood limestone is approximately correct. He locates it as probably being in number 7 or 6 of his section, which is near the top of number 22 of our section. Prosser refers numbers 13-15 of his section to the Wreford limestone,* giving it a thickness of 50 feet. In looking over his notes previous to writing this paper it was discovered that in passing over the section twice his barometer gave different readings for the covered portion of the section between the two flints and in compiling the section the smaller reading was used. This was also in accordance with the general appearance of the section. Even with the sides stripped as they were at the time of our visit it was very difficult to realize the thickness of the strata exposed between the upper cuts by

* Kans. Univ. Quart. vi, p. 152. Strong flint = Wreford limestone.

walking along the railroad. The upper part of the Wreford limestone was partially concealed as was most of the Matfield formation.[†] Number 13 of Prosser's section corresponds to numbers 41 to 45 of our section. Number 14 of his section corresponds to numbers 46 to 47 of our section, including the shales and upper limestones of the Wreford limestone and all of the Matfield formation. The remainder of our section, numbers 68 to 70, corresponds with number 15 of his section, and represents the exposed thickness, of the Florence flint.

From the foregoing it is clear that the Florence flint forms the crest of the "Flint Hills" west of Reece. From there west to El Dorado the railroad passes down the dip-slope of this stream. Proceeding south from Reece, changes begin to appear in the rocks making up the front of the escarpment. The Florence flint falls back to the west forming another small escarpment west of the town of Beaumont and the Wreford limestone has been removed from the notch through which the railroad passes in crossing the ridge, though it appears on the crest just north and south of Beaumont. The Wreford limestone outcrops in the streets of Beaumont, somewhat below the crest of the ridge east of the town which is formed by rocks of lower horizon.[*]

South of the Reece section the "Frisco" railroad climbs the escarpment with numerous cuttings which produce practically a continuous exposure. No attempt was made to go to the base of the escarpment to establish a section but a base was chosen about 200 feet below the Wreford limestone, possibly in the top of the Elmdale formation. The detailed section follows:

SECTION OF THE "FLINT HILLS" ESCARPMENT EAST OF BEAUMONT.

42.	Covered, to the base of the Wreford limestone in the crest of the hill south of the railroad	20 ft.	0 inches
41.	Shales, red and blue, disintegrated, showing in cut	8+ "	0 "
40.	Shale, indurated, blue calcareous	5 "	0 "
39.	Shale, calcareous disintegrated	3 "	6 "

† This correction also applies to the section published in U. S. Geol. Surv. Folio 109, p. 3, column 3.

* Sellards left the field at the close of the work at Reece.

38.	Limestone, massive, fine chert concretions in top	1	"	3	"
37.	Limestone, shaly, and calcareous shales, upper part, very fossiliferous	5	"	9	"
36.	Limestone, impure, some chert	2	"	0	"
35.	Shales, gray, and thin sheets of limestone	1	"	6	"
34.	Limestone, hard bluish, weathering buffish, layer of pelecypods on top	2	"	0	"
33.	Shales, olive, clayey	5	"	0	"
32.	Crusty deposit	1	"	0	"
31.	Shales, blue	2	"	0	"
30.	Shales, calcareous concretionary	2	"	0	"
29.	Shales, yellowish calcareous	3	"	0	"
28.	Limestone, blue, hard and slaty with some fossils	6	"	0	"
27.	Limestone, massive with occasional chert concretions, shaly above and cherty below. *Pseudomonotis*	5	"	6	"
26.	Shale, blue, hard, disintegrated, some fossils	3	"	0	"
25.	Covered to the base of the previous cut	10	"	0	"
24.	Shales	1	"	6	"
23.	Limestone, rotten	1	"	0	"
22.	Shales, light colored	12	"	6	"
21.	Limestone, rotten	1	"	0	"
20.	Shale	2	"	0	"
19.	Limestone	1±	"	0	"
18.	Covered to limestone 5 feet below previous cut	5	"	0	"
17.	Shales, yellow calcareous, some fossils	12	"	0	"
16.	Covered	15	"	0	"
15.	Shales, crusty	2	"	0	"
14.	Limestone, shaly above and massive below	8	"	0	"
13.	Shales, light colored, clayey, to base of last cut	10	"	0	"
12.	Limestone, massive, in three layers, *Fusulina* on top	6	"	0	"
11.	Shales, calcareous, with some fossils	3	"	0	"
10.	Shales, yellowish, to base of previous cut	12	"	0	"
9.	Limestone, shaly	1	"	0	"
8.	Shales, light colored, clayey	5	"	0	"
7.	Covered	5	"	0	"
6.	Limestones, two thin ones, with shaly parting	1	"	5	"
5.	Shales, blue, calcareous	5	"	0	"
4.	Limestone, massive, flesh-colored, gastropods, pelecypods and cephalopods	2	"	6	"
3.	Limestone, yellowish and impure, and shales fossils	5	"	0	"
2.	Shale, blue, some fossils	2	"	0	"

1. Limestone, gray, rotten	1	" 0	"
Total	206	ft. 3	inches

Numbers 1 to 10 are in the fifth cut on the big curve going east. Numbers 11 to 13 are in the fourth cut, 14 to 16 in the third, 17 to 19 in the second and 20 to 25 are in the first cut on the big curve going east. Numbers 26 to 33 are in the cut a half mile east of Beaumont junction and numbers 34 to 40 are in the first cut east of Beaumont. In other words the section beginning at number 40 and passing eastward down the escarpment along the railroad is exposed in the first seven cuts.

It seems probable that number 12 of this section is in the approximate horizon of the Cottonwood limestone, judging from its general appearance and position in the section, and number 13 carries a fauna similar to the Florena shales and has a resemblance to them. If this suggestion should prove to be correct the thickness of the Garrison formation at this locality would be 146 feet.

The two streams heading on the crest of the ridge have removed the Wreford limestone from the point where the railroad crosses the ridge as stated above, but appears on the ridge just south of the railroad.

Eighteen miles south of Beaumont is the Grand Summit region famous for its fossils. The logical approach to this region is from the north where the Beaumont section furnishes a valuable key to the conditions here.

This section will be considered in two parts, the Grand Summit, or lower, section and the Cambridge-Burden, or upper, section. The detailed section of the Grand Summit half follows:

GRAND SUMMIT SECTION.

29. Shales, blue, with calcareous sheets and millions of fossils	15	ft. 0	inches
28. Limestone, blue, clayey	1	" 0	"
27. Shales, blue, yellow above	5	" 0	"
26. Shales and shaly limestone	5	" 0	"
25. Limestone, somewhat massive, weathering light	8+	" 0	"
24. Shales, calcareous, and impure limestone.....	7	" 0	"
23. Shales, clayey, with calcareous layer, very fos-			

	siliferous	7+ "	0	"
22.	Limestone, clayey, nodular and clay shales. Some fossils	3 "	0	"
21.	Shales, yellow and blue with calcareous lenses. Sea urchins	5 "	0	"
20.	Covered, 5 feet to	8 "	0	"
19.	Shales, red	5 "	0	"
18.	Shales, blue	1 "	0	"
17.	Limestone, blue, massive	1 "	0	"
16.	Shales, yellow and red, 1 foot of limestone near the base	10 "	0	"
15.	Limestone, massive in one layer	3 "	0	"
14.	Shales, yellowish, calcareous	1 "	4	"
13.	Limestone, shaly	1 "	0	"
12.	Shales	0 "	4	"
11.	Limestones, two thin ones	0 "	4	"
10.	Shales	0 "	6	"
9.	Limestone, buff to brownish large *Fusulinas* and chert in the lower part	6 "	0	"
8.	Shales, clayey	1 "	9	"
7.	Limestone, shaly to massive	3 "	9	"
6.	Shales, yellowish	3 "	3	"
5.	Limestones, thin, with shale partings	3 "	0	"
4.	Limestone, massive, in two layers	3 "	4	"
3.	Shales, yellowish, with calcareous layers rich in fossils	9 "	0	"
2.	Limestone, dark colored, in thin layers full of pelecypods	4 "	0	"
1.	Shales, red and blue, in creek north of the cut, east of the trestle over the small creek	11 "	0	"
	Total	132 ft.	7	inches

There are somewhere from 90 to 125 feet of rocks in the hills to the north of Grand Summit which should be added to this section, but they are better exposed in the section which is to follow. The Wreford limestone caps the top of the hills north of Grand Summit and is in the big ridge west of town. The most conspicuous feature of the Wreford limestone here is the great blocks of semisilicified limestone, apparently formed by infiltration. This is a character of this limestone throughout its southern extent but more pronounced here than farther north. These blocks weather out brown and the farmers use them to fill mud-holes in the road, build fences, &c., calling them "sandstones."

They are very porous and light and have the smooth joint surfaces of chert. The top of the hill west of Grand Summit registered 90 feet above the town. Taking the dip into consideration this would add more than 90 feet to the Grand Summit section. The dip to the west is probably equal to the railroad grade.

The limestone quarried at Cambridge may be number 25 of our Grand Summit section, but it seems probable that it is one a little higher in the series. At Grand Summit there are four layers of limestone with intervening shale beds of considerable thickness, between the top of our section and the base of the Wreford limestone. The limestone quarried west of town at Cambridge is 94 feet below the base of the Wreford limestone. The latter is excellently exposed across the creek south of the quarry, where a fairly good section of the underlying rocks is to be had, on the point just east of the mouth of the little tributary from the south. The following section is a compilation of this exposure with those from the old Torrence station, just west of Cambridge, along the railroad to Burden. From Torrence (old station at the Creek) to Burden at the top of the escarpment almost all the strata are excellently exposed.

THE SECTION FROM CAMBRIDGE TO BURDEN.

39.	Chert concretions and weathered limestone, top of Burden cut	2+	ft.	0	inches
38.	Limestone, massive, with chert in layers	10	"	0	"
37.	Limestone with numerous chert concretions	10	"	0	"
36.	Shaly calcareous layer with some fossils	3	"	6	"
35.	Limestone, shaly, full of pelecypods	2	"	0	"
34.	Shales, dark red and blue	6	"	6	"
33.	Shales, bluish	3	"	0	"
32.	Bluish marl	1	"	0	"
31.	Shale, red	4	"	0	"
30.	Limestone, shaly below	2	"	0	"
29.	Covered	20	"	0	"
28.	Shale, bluish, and calcareous nodules	6	"	6	"
27.	Massive limestone, two layers	5	"	6	"
26.	Limestone, impure, shaly; shales on top	3	"	0	"
25.	Shales, blue and olive	8	"	0	"

24.	Limestone, massive, mottled and rough......	3 "	0	"
23.	Limestone with three thick layers of chert...	3 "	0	"
22.	Covered	8 "	0	"
21.	Olive shales	2+ "	0	"
20.	Shale, yellow, arenaceous	1 "	0	"
19.	Limestone, massive, chert in top.............	1 "	6	"
18.	Limestone with large chert concretions......	6 "	0	"
17.	Limestone, partially silicified and carrying chert............	1 "	6	"
16.	Limestone with coarse chert concretions.....	4 "	6	"
15.	Limestone full of small chert concretions.....	5 "	0	"
14.	Shales, calcareous and impure limestones, *Derbyas*	8 "	6	"
13.	Clay shales	9+ "	0	"
12.	Shales, red	5+ "	0	"
11.	Covered	15 "	0	"
10.	Limestone, rough, massive..................	3 "	6	"
9.	Shales	8 "	6	"
8.	Limestone, fossiliferous	1 "	0	"
7.	Covered	5 "	0	"
6.	Limestone, springy slope beneath, (S. of Cambridge quarry)	3± "	0	"
5.	Covered	34 "	0	"
4.	Shales, blue, slaty, calcareous, in quarry.....	4 "	0	"
3.	Limestone, hard, massive, fossiliferous.......	0 "	9	"
2.	Limestone, massive, hard	2 "	6	"
1.	Covered to creek bed	41 "	0	"
	Total	254 ft.	3	inches

Numbers 2 and 3 are exposed in the quarry west of Cambridge. Lithologically the stone of this quarry is strikingly like numbers 27 and 28 of the Beaumont section, which would be somewhat above number 25 of the Grand Summit section. However Prosser is of the opinion that the rock in the Cambridge quarry is identical with number 25 of the Grand Summit section.* On the whole the Grand Summit section and the Cambridge to Burden section are to be considered as continuous. Whether or not numbers 2 and 3 of the Cambridge section are the same as number 25 of the Grand Summit section is a matter of minor importance to the consideration of the sections as a whole. Numbers 15 to 24 represent the Wreford limestone with a thickness of

* Kans. Univ. Quart., vi, p. 166. This limestone he correlated with the Wreford limestone (= Strong flint).

35 feet 6 inches. Numbers 25 to 36 represent the Matfield formation with a thickness of 59 feet, while numbers 37 to 39 are the Florence flint, 22 feet of which is exposed.

Adams ran a generalized section over this same railroad from Grenola to Grand Summit and Burden. However the only section he gives is that of plate ix which appears to be entirely generalized.† He correctly states that Burden is higher geologically than Grand Summit. However he represents the dip to the west as being much less than the slope while in fact it is about as steep as the railroad grade. In other words he represents almost all of the Burden section as being a repetition of the Grand Summit section while as a matter of fact none of the rocks are repeated. He also shows the same layer of limestone appearing in the escarpment east of Grand Summit, at Grouse creek, Little Cedar creek and the Walnut river at Winfield, while the writer finds the rocks occurring in the latter place (Fort Riley limestone are stratigraphically above those at the top of the grade at Burden. It is possible, however, that his whole section is but a generalization and the plate merely illustrates that the rocks dip to the west in a general way with no attempt to represent it accurately, or show the relation of the strata.

According to Adams the dip is 10 feet to the mile to the west. Cambridge is five miles west and four miles south of Grand Summit, and the difference of elevation between the two places is 193 feet,* but the difference in altitude between number 27 of Prosser's section and the quarry at Cambridge is given as 145 feet making the dip, as given by Prosser, 16 feet per mile to the south west. However, the dip is probably more to west than to the southwest, so that it would be greater in a westerly direction than is shown between Grand Summit and Cambridge.

The first account of the Grand Summit section was published by Broadhead in 1883 or 1884.† This paper was a generalized one and is amply discussed by Prosser.‡ Broad-

† A section from Galena to Wellington. By G. I. Adams., Univ. Geol. Surv. Kans., I, p. 27, pls. 1, ix, 1896.

* Bull. U. S. Geol. Surv., 160, pp. 2[illegible], 2[illegible], 1[illegible]. The elevations given are 1438 and 1245 feet, respectfully.

† Trans. St. Louis Acad. Sci., iv, pp. 4[illegible], 4[illegible].

‡ Op. cit. pp. 1[illegible]-1[illegible].

head considered number 11 of his section as Permian. This corresponds to number 5 of Prosser's section and is considerably below the base of our section. At the time Prosser's paper was written the Cottonwood limestone was considered the base of the Permian. He correlated number 17 of his section, provisionally, as the Cottonwood limestone and number 18 as the base of the Permian. This is still below the base of our section.

Unless one has seen the section at Beaumont or the one from Torrence to Burden it would be difficult to get the proper understanding of the Grand Summit section. Broadhead, Adams and Prosser ran sections over the Grand Summit ridge, but Adams alone studied the section from Cambridge to Burden, and should have given it the proper interpretation. They considered the ridge on which Grand Summit is located as the "Flint Hills" escarpment and its rocks the equivalent of those found occupying a similar position farther north. Several facts contributed to this error. In the first place the limestones of the Garrison formation have become more conspicuous and misleading in this region and, secondly, the opposition of the heads of rather large streams on either side of the escarpment has tended to increase the hight of its eastern face and at the same time has removed the upper strata completely. At Grand Summit the thick limestone, by the upper cut, weathers strikingly like the less cherty portions of the Wreford limestone. This limestone is represented in number 28 of Prosser's section near the top of number 1 of Broadhead, and is number 25 of our section. Number 28 of Prosser, the fossiliferous layer, was supposed to be the fossiliferous horizon in the middle of the Wreford limestone, as at Council Grove and some other localities. Number 28 of Prosser's section is equivalent to number 29 of ours. Numbers 27 and 20 of his are the same as numbers 25 and 1 of ours, respectively.

From what has preceded it will be clear that the heavy limestone by the last cut at Grand Summit is not the Wreford limestone but is stratigraphically at least 90 feet below it, as are the quarries at Cambridge. This change in the interpretation of the stratigraphy is very important to the paleon-

tologist as it places the great fossil horizon at Grand Summit in the Garrison formation instead of in the Permian.

The horizon of the Cottonwood limestone can not be located with certainty, but it may be near number 9 of our section.

The appearance of the exposure of the lower Wreford limestone in the cut east of Dexter, Cowley county, is typical of its southern extension, showing well the imperfectly silicified limestone, "sandstones" of the inhabitants, and heavy chert layers. In this region local structure becomes a factor in studying the stratigraphy of these rocks. The writer hopes to be able to complete the study of the stratigraphy of his county the coming season. In the mean time, however, it is well to correct the section of the bluffs north of Arkansas City, measured by Beede in the summer of 1896. This section was measured in the evening at a bad exposure and further study of better exposures gives the following section. The first section was published by Prosser.*

SECTION OF BLUFF NORTH OF ARKANSAS CITY.

12.	Limestone, fossiliferous, porous	10	ft.	0	inches
11.	Shales, yellow calcareous	2	"	6	"
10.	Limestone, rotten clayey	2	"	0	"
9.	Yellow shales	2	"	0	"
8.	Covered	2	"	0	"
7.	Limestone	1	"	8	"
6.	Shale, yellow	5	"	0	"
5.	Shale, blue and green	15	"	0	"
4.	Limestone	0	"	4	"
3.	Covered	7	"	0	"
2.	Limestone	1±	"	0	"
1.	Covered to level of bottom land	10	"	0	"
	Total	59	ft.	0	inches

Prosser† was inclined to refer this section to the Marion formation and the exposure on the opposite side of the Walnut river, east of the Santa Fe depot, to the Winfield formation. However, in the light of the better section and the concretions on the ground, on the bluffs north of the city, it seems seems probable that number 6 of this section is the

* Op. cit. p. 174.
† Op. cit. p. 174.

Winfield limestone and that the remainder should be assigned to the Doyle shales while the limestone east of the Walnut probably represents the Fort Riley limestone. However this is merely a guess and the stratigraphy will have to be worked out before the matter can be settled definitely.

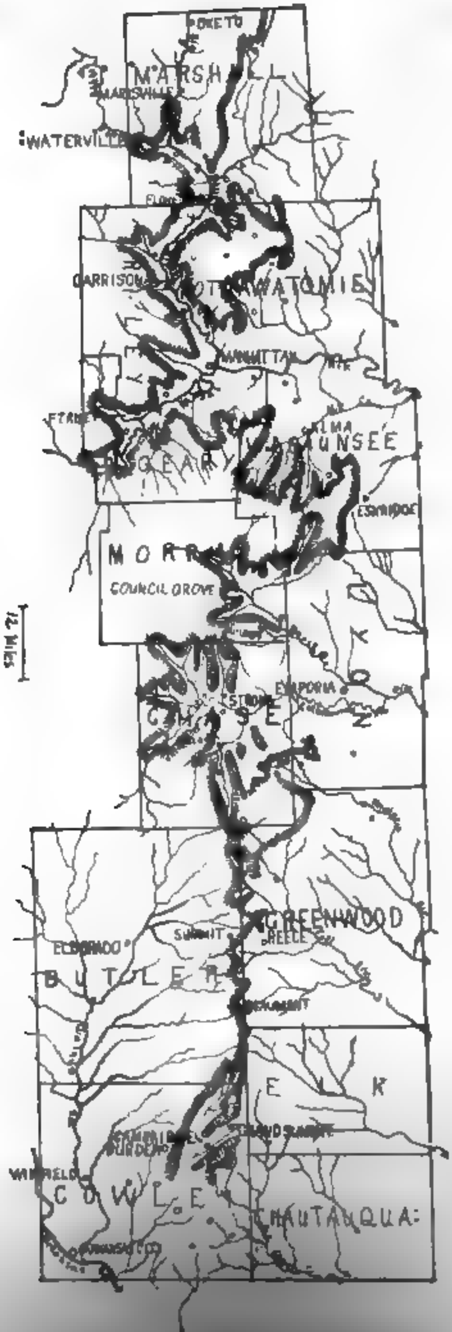
CONCLUSION.

From what has preceded it will be seen that the strata of the lower Permian are remarkably persistent and uniform when the great extent of the outcrop is considered. The Cottonwood limestone, though only about six feet thick persists with every detail of structure and fauna over one-hundred miles of strike and several times as great an outcrop, though it has not been identified with certainty in the southern part of the state. The Garrison formation extends entirely across the state with but slight modifications in the southern part, such as the thickening of some of its limestones and the possible interpolation of others. The Wreford limestone is remarkably uniform throughout the entire distance from Nebraska to the southern line of Kansas, being most highly developed in the central part of its outcrop in the region of Cottonwood Falls. In the Matfield shales about the only change worthy of special notice is the thickening of a layer of limestone and the coming in of an additional one in the southern part of its outcrop. There are no striking changes in the Florence flint aside from a slight fluctuation in its thickness, being somewhat thicker in the central and southern regions.

Three maps have been published which show either in part, or in a general way the whole outcrop of the Wreford limestone and associated strata in Kansas. The first was published by Beede* and shows the outcrop, in a general way of the Cottonwood formation, Neosho, Chase and Marion stages in the region north of the Kansas river. The line between the Neosho and Chase stages is the line of outcrop of the Wreford limestone.

The second was published by George I. Adams in an article entitled "Physiographic divisions of Kansas† and shows in a very general way the location of the "Flint Hills

* Kans. Univ. Quart., ix, pl. xliii, 1900.



THE MAP OF THE OUTCROP OF THE WREFORD LIMESTONE IN KANSAS.

Escarpment" in Kansas. The map of Kansas is a little less than three inches by six in his article. The location of the escarpment north of the Kansas river was taken from Beede's map.

The third of these maps is to be found in the Cottonwood Falls folio of the U. S. Geological Survey.‡ This map shows the details of the stratigraphy of the rocks within its area discussed in this article, and to it the reader is referred for an idea of the intricate nature of much of the outcrop of the Wreford limestone.

The data of the first and last maps mentioned were used freely in constructing the accompanying map, on which is shown the outcrop of the Wreford limestone. The line between Eskridge and Junction City is hypothetical a part of the way, as it is locally, though always in very much shorter distances, in a few other places. The width of the stream-etched portions of the escarpment is purposely enlarged for the sake of clearness. Southern Cowley county has not yet been mapped.

† Trans. Kans. Acad. Sci., xviii, 1903.
‡ Cottonwood Falls Folio, U. S. Geol. Surv. Atlas, number 109, Prosser and Beede, 1904.

THE FUNDAMENTAL COMPLEX BEYOND THE SOUTHERN END OF THE ROCKY MOUNTAINS.

By CHARLES R. KEYES, Socorro, New. Mex.

Soon after passing the southern boundary of Colorado the Rocky mountains rapidly dwindle and disappear as a pitching anticline beneath the plains of the Mexican tableland. In this limited New Mexican area the Archæan, or Azoic, rocks form the cores of several of the principal ranges. The last exposure of the fundamental complex is in the Apache canyon, which the Atchison, Topeka and Santa Fe railway makes use of in crossing the mountains. South of this locality the only exposures of ancient crystallines are in the great fault-scarps of the block mountains, which rise out of the plains, forming the general surface of the Mexican tableland and the New Mexican portion of the High Plateau region.

During recent years many facts have been brought to light which have very radically modified opinion regarding the great crystalline basement underlying all the Paleozoic sequence in New Mexico. Most of the extensive formations composed of granites, schists, and gneisses which form the axial foundations of so many of the mountain ranges of the region are now believed to be of much later geological age than is generally understood to be covered by the title, Azoic or Archæan.

In summing up our knowledge on the subject, a decade ago, in his paper, the Pre-Cambrian Rocks of North America, Van Hise* remarked:

"It is evident from the literature that in western New Mexico and in the major part of Arizona is a fundamental, thoroughly crystalline complex, consisting of most intricately mingled and folded granites, gneisses, micaceous and hornblendic schists, etc., precisely as in the previous sections concerned with the Rocky mountain system. This complex occurs at many points, constitutes the axes of many ranges, and its structure is of so intricate a character that no attempt has been made to estimate its thickness or to work out its structure, although in general the laminated rocks have been referred to as metamorphic. The granite in this complex plays the same part with reference to the crystalline schists as in the other areas referred to. Besides this ancient granite, which existed before the next newer series of rocks was formed, there is apparently

* Bull U. S. Geol Surv., No 86, p. 331, 1892.

in certain areas granites of later age, and these are more plentiful as the western part of Arizona is reached."

In the light of the recent discoveries that in some of the mountain ranges of New Mexico portions at least of the crystalline foundation are of clastic origin, it becomes necessary to devise criteria by which the crystallines of the fundamental complex (Archæan) may be separated from those that have a sedimentary origin. Until the application of these criteria to every mountain range is made, no general deductions can be drawn concerning the exact ages of the different crystalline formations. The reasons for this statement are obvious from even a casual examination of the basal crystallines in New Mexico. It is known that in all of the New Mexican mountains where the crystalline basement is open to view a marked unconformity exists at the base of the fossiliferous sequence. The late Carboniferous limestones generally rest directly upon the granites, gneisses and schists, the foliation of which is more or less steeply inclined or even vertical.

That the erosion interval represented by the unconformity was very long is quite evident. In southern New Mexico the early Carboniferous limestones begin to make their appearance. Then come Devonian beds, Silurian or Ordovician, and finally what appear to be Cambrian. A horizon of great unconformity persists under all the Paleozoics.

Something of real significance of the old erosion plain becomes manifest by reference to the geological section displayed in the Grand Canyon of northwestern Arizona towards the western border of the High Plateau region. The author* just quoted describes the following general conditions:

"The Tonto sandstone of the Grand Canyon region, called by Powell and Gilbert Silurian in accordance with the nomenclature of the time, by present classification is to be placed as Upper Cambrian. The great unconformity which separates this sandstone from the earlier series makes it very probable that the latter are pre-Cambrian. These inferior series in descending order are the Chuar, Grand Canyon, Vishnu series (together the equivalents of Powell's

* Loc. cit., p. 881.

Grand canyon group), and the basal complex. The upper series consists of shales and limestones. Below this, with an erosion interval, is the second, consisting of sandstones, with interbedded and cutting basic eruptives. Inferior to this series, and separated by a great unconformity, is a set of thinly bedded and nearly vertical quartzites of undetermined thickness, broken by intrusive masses of granite. These three are clearly clastic series. The basal complex as described by Powell and Gilbert consists of thoroughly crystalline hornblendic and micaceous schists, gneisses, and granites, like the fundamental complex of the remainder of New Mexico and Arizona. Between this basal complex and the Vishnu series, as shown by Powell, is a vast unconformity. We have then in this region passing from the base upward, a fundamental complex; great unconformity; quartzite series of unknown thickness (Vishnu); great unconformity; Grand Canyon series; minor unconformity; Chuar series; great unconformity; Cambrian."

There are then recognizable in the Grand Canyon part of the region at least four great unconformities in the space between the undoubted fundamental complex of Archæan age and the Cambrian sandstones. Each of these four unconformities represents a long period of time when the rocks were elevated above the sea, flexed and then subjected to enormous denudation. Powell[†] has estimated that in the case of the latest of the intervals mentioned which is represented at the base of the Cambrian sandstones, at least 10,000 feet of beds were bowed up, contorted and eroded in such a manner as to leave but fragments in the synclinals.

Each of the great unconformities represents similar conditions. In New Mexico these four periods of enormous erosion were probably superimposed. The clastics of the Proterozoic must have suffered tremendously. Over very large areas every vestige must have been removed. In all likelihood only scattered remnants remained. Thus in adjoining mountain ranges the crystalline basement may be of Archæan age in the one case, while in the other it may be Proterozoic.

The differentiation of the fundamental Azoic complex from the Proterozoic crystallines must rest upon the application of some such scheme of critical criteria as has been so successfully formulated in the Lake Superior region.

While there is as yet much uncertainty regarding the

† U. S. Geog. and Geol. [illegible] 1876.

position and geological age of the basal crystallines in many of the different mountain ranges there are some instances in which there exists but small doubt as to their Azoic position. The general proofs are in a measure comparative. They are the relative amount of metamorphism evidenced, the character of the deformation apparent, the difference in petrographical features, the geological relationships, the absence of all evidences of clastic origin, and a comparison with similar features of known areas in other parts of the country.

The literature relating to New Mexican Azoic formations refers all the basal crystallines to the Archæan. Little of definite value therefore can be gleaned grom the widely scattered published descriptions of local phenomena. The first suggestion that any portion of the ancient crystallines occurring within the boundaries of New Mexico were any other than of Archæan age is believed to be a recent statement regarding the significance of the recent identification of certain "quartz-reefs" in the Sandia mountains as highly metamorphosed sandstones.*

The present surface exposure of the great crystalline basement underlying all the fossilferous strata in New Mexico is relatively small. Aside from the area in the southern Rocky mountains in the northern part of New Mexico the exposures of pre-Cambrian rocks are confined almost to linear outcrops found along the immense fault-scarps of the block mountains. Some of these outcropping faces indicate that the rocks are of undoubted Azoic or Archæan age, while others are manifestly of clastic nature and thus belong to the Proterozoic.

In order to understand more fully this apparent anomalous distribution it is necessary to refer to some of the general conditions prevailing in neighboring states that the geological history discloses. The conception is that the upper surface of the ancient crystalline basement in this region represents an old peneplane on which, when submergence took place in Proterozoic times, an enormous thickness of sedimentaries was laid down. This whole country, still in pre-Cambrian times, was folded up into mountain

* Eng. and Mining Jour. vol lxxvi, p. 967, 1903.

ranges, not once, but repeatedly. Finally before the Cambrian strata of the region were deposited the entire country, already profoundly folded, faulted and cut frequently by intrusives was planed down to a prodigious extent. On this new peneplane only isolated patches of the clastic rocks of Proterozoic age survived—only those portions caught in the lowest parts of complex troughs, the bottom of synclinoria. These remnants of the Proterozoic sedimentaries now appear so intensely metomorphosed that they have until quite recently entirely escaped notice. At best it is only with the greatest difficulty that the rocks of the two great ages can be differentiated.

In many of the mountain ranges the crystalline basement is composed partially or entirely of gray or red granites which show little or no evidences of shearing or subjection to great oroganic pressure. It has been customary to regard these masses as composed of Archæan granite. Now granites of this description, practically unaltered, are known to traverse or be intimately associated with the undoubted Proterozoic crystallines. On the principles involved in the separation of unfossiliferous geological formations according to the relative amount of deformation and comparative degree of metamorphism, these unaltered granitic masses are tentatively referred to the Proterozoic, though for convenience in treatment some of them probably have to be considered for the present in connection with the other rock-masses in which they occur.

At some risk, perhaps, in the present state of our knowledge, of swinging too far in the direction opposite to that heretofore generally accepted, it seems most advantageous to proceed on this hypothesis. In support of this position there are many other reasons which should be fully discussed in connection with the detailed descriptions of the Proterozoic crystallines. For the present only those crystalline rock-masses will be considered as belonging to the Archæan fundamental complex, that consist of much sheared granites, crumpled gneisses and schistose rocks not associated with undoubted clastics.

Probably the main reason for the lack of definite and discriminating information regarding the pre-Cambrian

rocks of southwestern United States has been the comparatively limited exposures. Another factor has been that the examination of the formations has been an incidental object in connection with hurried expeditions undertaken for other than geological purposes. In New Mexico the exposures of the pre-Cambrian crystalline basement are for the most part linear in character. There are in this region a score of prominent mountain ranges in which the basal crystallines are exposed to view. At least in half of this number the rocks are with but small doubt of Azoic age. Several ranges present crystallines which are of undoubted clastic origin. In the remainder the age of the crystallines is not definitely known.

Most of the ranges will have to be studied anew in the light of the more modern conceptions rendering possible the differentiation of the old crystallines into well defined geological formations. In the southern Rockies, which extend down from Colorado less than a third of the distance to the southern boundary of New Mexico, there are four large areas of basal crystallines all of which, until undoubted clastics are discovered in them, may be considered as composed of Azoic formations. As a whole the ranges which collectively go to make up the southern extremity of the Rockies are generally known as the Snowy mountains or the Sangre de Cristo ranges. As the four areas of Azoic rocks mentioned are more or less distinctly separated from one another, they will be here taken up briefly in turn.

The largest and most important area of ancient crystallines occurring in New Mexico is the one entering from the north from Colorado. Comprised within the area are the two important ranges, Culebra, and Taos, which are almost wholly made up of old crystallines. The principal rocks are hornblendic schists, biotitic schists, gneisses, gneissoid granites and coarse-grained unmodified granites. Stevenson* frequently mentions in this and neighboring districts the existence of beds of quartzite in the granitic and gneissic rocks. Whether or not all of these "beds" are really quartzitic clastics cannot now be told. From what is personally known of the character of the rocks generally in this region

* U. S. Geog. Sur. W. 100 Merid., vol. iii, Supp., p. 68, 1881

it is not believed that any of them are of clastic origin. Some of them are certainly aplitic; and others are known to be quartz-veins inclined at low angles.

According to the writer just mentioned, the rocks immediately north of the boundary line in Colorado are predominantly hornblendic schists, though there are some mica schists present. These schists occupy the middle and highest portions of the axis. On the east side of the range gneisses and gneissoid granites prevail, together with some mica schists. A coarse-grained granite is also frequently met with.

Southward, within the limits of New Mexico, the hornblendic schists become less and less prominent. At the boundary line the Azoic belt is not more than 6 or 7 miles in width, but within a short distance it rapidly broadens out to 20 miles. The prevailing rocks are dark and light colored gneisses, some bands of the latter very closely resembling beds of quartzite. Occasionally bodies of coarse-grained granites are met with.

Bordering the front of the Rockies, from a point near the northern boundary of New Mexico and extending southward a distance of over 30 miles, is a rugged ridge known as the Cimarron range. These mountains are composed largely of Tertiary eruptives. Where the range is deeply cut by canyons which traverse it, as for example on the Rayado, the Cimarron, and several branches of the Vermejo, Azoic rocks are disclosed beneath the spread-out eruptives. These old crystallines are chiefly light colored micaceous schists and dark hued fine-grained gneisses. Occasionally these rocks are broken through by coarse-grained red granites.

In the southern part of the range the base of crystallines is covered by basalt flows from the great Ocate crater, which rises out of the plains a few miles to the southeastward.

The areal distribution and the structural relationships of the Azoic basement in the southern part of the Cimarron range are at present somewhat obscure. The apparent irregularities in the distribution of these rocks is probably due largely to the presence of the Mora arch which extends in a

northwesterly and southeasterly direction through the Turkey mountains. The genesis of this arch is probably of quite recent date. It crosses the great fault that runs along the eastern front of the Rockies which late erosion has greatly obscured at this point.

The Azoic core of the Las Vegas and Mora ranges forms a narrow belt which begins a few miles north of the crossing of the Pecos river by the Atchison, Topeka and Santa Fe railroad and extends northward a distance of 65 miles. It is bordered on each side by wide belts of Carboniferous limestone. The most prominent peak is Solitario, which rises to a hight of 10,260 feet above sea-level.

At the northern extremity, the rocks appear to be almost entirely hornblende schists. A few miles to the southward light colored micaceous schists and gneisses are the prevailing rocks, with some dark colored gneisses occupying the central portion of the belt. At Mora the principal rock is a gneissic granite, while farther on appear again the micaceous schists. From the Cebolla canyon the gneisses and schists appear to be profoundly affected by deformation agencies. From Solitario peak southward the predominant rock is a coarse-grained granite with occasional bands of gneiss.

The east side of the Rio Grande valley in northern New Mexico is bordered by the lofty Santa Fe mountain range, the highest peak of which, known as Baldy, is 12,660 feet above the sea-level. The central axis of this range is comuosed of ancient crystallines bordered on each side by Carboniferous rocks. The crystalline belt is 50 miles long, by 6 to 8 wide in the broadest place. At the southern end in the Apache canyon the prevailing rock is a red granite. Granite bands and masses appear at frequent intervals farther north in the gneisses and micaceous schists. In the Santa Fe canyon there occur in the gneiss bands of argillaceous slate. Farther north the rocks present similar geological characters.

Archæan granites are reported by Stevenson as composing the Placer (Ortiz) mountains, 20 miles south of Santa Fe. No granite is found in these mountains. The rocks are micaceous and augitic andesites of laccolithic origin,

and probably of early Tertiary age. The same is true of the neighboring Los Cerrillos hills, the Cerro Pelon, the Tuertos group, and the San Ysidro.

Thirty miles west of the Rio Grande, and about the same distance north of the city of Albuquerque are the Nacimiento and Jemez mountains. The first mentioned of these is a block mountain 20 miles long. Along the great fault scarp, and under the Carboniferous limestones forming the backslope, the basal crystallines are well exposed. These appear to be chiefly granites, so far as observation goes. Their age is as yet undetermined. They are for the present referred to the Azoic.

Near the continental divide west of Albuquerque is located the Zuni dome, its top eroded off down to the crystalline basement. The age of the pre-Carboniferous crystallines is presumably Azoic. As early as 1856 Marcou* mentions a belt of crystallines in the heart of the Zuni range 12 miles wide, consisting of reddish granite, gneiss and schist. Blake† also calls attention to the gneisses and granites of this district, and corroborates Marcou's observations. In Dutton's‡ account of the Zuni plateau the presence of gneisses or schists is not mentioned. The granites are called Archæan. If, however, the observations recorded are correctly interpreted some of the granites are certainly of much later intrusion. This author states that they have metamorphosed the overlying Carboniferous limestones, and calls particular attention to this phenomenon as it is well displayed in Mt. Sedgwick, the most prominent feature in the field.

The remarkable mountain blocks known as Sierras Oscura and San Andreas are over 100 miles long and extend northward from the Organ mountains north of El Paso. The fault-scarps of the two ridges face each other at their proximate extremities, a flat valley lying between the two. Herrick* mentions the granitic character of the crystallines beneath the the Carboniferous limestones, which dip in opposite directions in the two ranges. The age and lithologic

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* Pac. R. R. Sur., vol. iii, p. 170, 1856.
† Pac. R. R. Sur., vol. iii, p. 35, 1856.
‡ U. S. Geol. Sur., 6th. Ann. Rept., p. 158, 1885.
* Bull. N. M. Univ., vol. ii, Fasicle No. 3, p. 6, 1900.

character of the crystalline basement are presumably similar to those of the Organ mountains, immediately to the south, which have in fact a genetic relationship to the San Andreas range.

While properly a continuation of the San Andreas and the Franklin mountains to the south the Organs belong to a distinct block which has been elevated much more than any other portion of the long ridge to which they belong. In consequence the sedimentary rocks have been entirely removed except at the very base on the west side.

The rocks of the Organ mountains are chiefly red and gray, coarse-grained granites. Associated with these are hornblendic and micaceous schists, which are traversed by numerous dikes, which are quartzose, dioritic and andesitic in character. Proterozoic quartzites and clay slates are well developed a few miles to the south, in Texas, and it is probable that these also extend into New Mexico. According to Walcott the thickness of the pre-Cambrian clastic section is over 3,000 feet.

In Perry's notes* on the geology of the Mexican boundary mention is made of the granites underlying the Carboniferous limestone of Franklin mountain north of El Paso and in the Organ mountains, but no specific reference is made to their age. G. B. Shumard† passed through the Organ mountains in 1857 and noted on the east side hornblende and mica schists, and red and gray granites, all of which were cut by dikes of quartz, greenstone and porphyry.

Thirty miles west of the San Andreas range the Caballos mountains rise abruptly above the Rio Grande valley. These form a block mountain in which the crystalline basement is exposed for a vertical distance of 1,500 feet. Biotitic schists, gray crumpled gneisses, and granites form the principal rocks. The granites are of two principal kinds. One, which is more closely identified with the gneisses, is gray, rather fine-grained and contains a large amount of quartz. The other is a coarse-grained, red granite, which appears to be a late intrusive, though it does not penetrate

* United States & Mexican Bound. Sur., vol. i, pl. ii, p. 8, 1857.

† Jour. Geol. Obs. Texas and New Mexico, in 1855-6, p. 113, Austin, 1886.

the overlying Carboniferous limestones. So far as has been observed there are no evidences of the existence of clastic rocks associated with these gneisses.

In the Santa Rita mountains, in Grant county, the basal crystallines underlying the Paleozoic limestones are composed chiefly of schists. The exposures are small, and little detailed information on the subject is at present available.

The great Mogollon uplift in western New Mexico appears to have an extensive foundation of ancient crystallines. The region is so covered by late eruptives that most of the former exposures are covered up. The same conditions prevail in the neighboring parts of Arizona. Reagan* appears to have found evidences of the presence of both Archæan and Proterozoic formations. The rocks of Azoic age consist of micaceous, talcose, chloritic, and hornblendic schists, and some granites.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Two Islands, and what came of them. THOMAS CONDON. pp. 211, pls. 30. Portland, Oregon, J. K. Gill Company, 1902, $1.50.

While the author of this volume attempts to supply a popular rather than a scientific want, yet the treatment of the geology of Oregon is thoroughly scientific. The author is a well known geologist who has alone represented Oregon in geological work and geological literature for a life-time. In his declining years he has gathered together the leading facts, discovered mainly by himself, and has in this book preserved them to science, and to the credit of his own labors. He has a large collection of Oregon vertebrate fossils, and he has supplied others to eastern paleontologists. The writer has known of his vigorous activity since the days of his earliest geological work.

The two islands described are named Shoshone and Siskiyou, the former in the northeastern part of the state,, in the region of the Blue mountains and the latter in the southwestern corner, extending into northern California, occupying what is now the Sis-

* American Geologist, vol. xxxii, pp. 267-308, 1903.

kiyou mountain region. The author traces the development of these islands into Oregon, and notes the changes of animal life as the development progresses. These islands each had a nucleus as early as the Triassic; they expanded through the Jurassic and had continuous increase in area through the Cretaceous.

The Cretaceous was closed by an important geologic and geographic event, the upfold of a colossal sea dyke. This dyke grew into the Cascade and Sierra Nevada range. It separated these islands, the Shoshone being enclosed on the east and thence forward associated with fresh water, and the Siskiyou on the west left still subject to marine conditions. This gave the islands different life histories, that of the Shoshone being characterized by land animals whose remains were washed into the lake in which the island stood, and that of the Siskiyou by beautifully preserved Eocene marine fossils. The Miocene was introduced by the slow initiation of the Coast range uplift, forming finally a Coast range valley between the Cascades and the Coast range which is traceable from southern California to Queen Charlotte's sound though having different names in its various parts—the San Joaquin, Sacramento, Willamette, Puget Sound.

The fresh waters on the east side of the Cascade uplift were gradually reduced in area, from lakes connected by streams to broad low valleys through which single streams flowed. These inland lakes laid the foundation for the drainage southward of the Colorado river, and that northward of the Columbia river. The Eocene climate was that of the palm and of the rhinoceros, moist and warm. The elevation and continuity of the Cascade range were not then sufficient to exclude the warm moist atmosphere of the Pacific. Much of the present area of Alaska, as pointed out by the author, was yet under the ocean, and there was presented an open passage for the Japan current, flowing eastward on its way to the Hudson bay and the coast of Greenland, thus "cutting off all accumulations of ice between Oregon and the Arctic ocean." These subtropical conditions were gradually changed to more temperate, and even Arctic, by the increasing elevation of the Cascades and the exclusion of the Japan current. This change was accompanied by the loss of the rhinoceros and the palm tree, the introduction of Miocene animals and plants and finally the Pliocene.

At the close of the Eocene the Shoshone island was joined to the eastern mainland. The larger mammals then swarmed over the island. These were Oreodon, Rhinoceros, Entilodon, Bothrolabis, various small rodents, cats like the cougar, dogs, diminutive horses having three hoofs instead of a single hoof, the composite genus Anchitherium.

With the introduction of the Pliocene the Miocene strata were slowly and unevenly elevated, the Miocene lakes were drained and large quantities of igneous rock were thrust upward through great orifices in the strata. The Pliocene lakes were smaller and their

sediments are marked by two characteristic fossils which run through them all, the camel and the horse. The horse was of numerous forms, the most noteworthy being Hipparion and Protohippus. The camel was in two groups, the camel proper and the Anchenia, the former perhaps as large as the Arabian camel and the latter about the size of a goat. Fossil remains of the real horse, indicating an animal about as large as a good sized dray horse of to-day have also been found in the Pliocene and were described by Prof. Condon in 1866, the earliest in North America.

The author divides the Pliocene of Oregon into two groups, the Dalles and the Silver Lake groups and gives notes of their vertebrate remains. It is in the latter that he found, associated with remains of camel and other Pliocene fossils, obsidian arrow points indicating that man lived in Pliocene time in Oregon. Prof. Cope accepted that conclusion, but Prof. Condon supposes that the case is not proven, since the human implements may have reached their position by simple gravitation through the denudation of some thickness of Pliocene strata which originally may have separated them from the camel bones. The existence of sand dunes in the immediate vicinity, suggesting powerful winds, and the fact that the bones and the arrow heads are mixed promiscuously on the bare surface, give some shadow of plausibility to this supposition. But it is plainly necessary to subject the region to an extensive and more detailed survey before it will be possible to pronounce positively on this question. *Prima facie* the evidence points as Cope concluded, but owing to the importance of the conclusion it may be best to hold it in abeyance.

The "surface deposits" are those that have accumulated since Pliocene time, bogs, swamps and all slight depressions in which large mammals often sink to their death. They are Pleistocene and contain the remains of mammoth, mastodon, the broad-faced ox and the sloth-like Mylodon. "A large part of this geological period overlaps that of prehistoric man." Up to the Glacial period the horse and the camel were abundant in Oregon and their continuance through Glacial times is still in doubt.

The author devotes a chapter to "The Willamette Sound." This body of water covered the Willamette valley and was connected with the Pacific. It was an incident of recent changes of level along the coast of Oregon and Washington. The sediments are thick, nicely stratified and in some places contain great numbers of fossils of recent shells mostly identical with those now living along the shore. The waters of this sound rose to at least 350 feet higher, relative to the land, than the Pacific ocean of to-day, and they buried the whole region under a fine loess which reaches the thickness of over 100 feet and forms the present soil and subsoil of the valley. The author does not indicate what may have been the chronological relation of this sound to the Pleistocene, or to any part of it. No human remains have yet been found in its sediments.

The latest geological event seems to have been the rise of the land to its present attitude, accompanied perhaps by volcanic activity in some of the peaks of the region.

The book is a very useful compend. It would have been improved by an index and still more by an outline map of Oregon. On the map could have been expressed various localities which the unfamiliar reader would have referred to eagerly, and it might also have shown some geological data. N. H. W.

Ice or Water: Another Appeal to Induction from the Scholastic Methods of Modern Geology. By SIR HENRY H. HOWORTH. In two volumes. Vol. I, pp. liii, 536; Vol. II, pp. viii, 498. Longmans, Green and Co., London, New York, and Bombay, 1905.

In these controversial volumes, published a few months ago, Sir Henry Howorth returns with redoubled zeal to his warfare against the glacialists. All extant or even obsolete theories of the causes of the Ice age are reviewed and analyzed. Weighed in the author's balance, they all are found wanting; none seems to him accordant with sound physical principles, and competent to explain continental glaciation. Therefore, in his judgment, the Ice age, in which the glacialists believe, must be a myth, merely a figment of their imagination.

To follow this destructive criticism, however, a constructive third volume is promised, completing the series thus entitled, which last volume will be devoted to exposition of the author's theory of the origin of the drift by the agency of rushing waters or floods, the renowned debacles of geologic science two or three generations ago.

From his early studies and publications, "A History of the Mongols," and "Chingiz Khan and his Ancestors," which led our author through central and northern Asia, he first came forward to challenge glacial doctrines in a memoir most amply illustrated by Siberia. This was "The Mammoth and the Flood, an Attempt to Confront the Theory of Uniformity with the Facts of Recent Geology" (pages xxxii, 464; London, 1887).

Six years later, he again assaulted these doctrines of glaciation, imputing them to wild imagination, such as gives affrighting dreams, in "The Glacial Nightmare and the Flood, a Second Appeal to Common Sense from the Extravagance of Some Recent Geology" (two volumes, pp. xxviii, 376, and xi, 377-920; London, 1893). In a considerable degree the new volumes cover the same ground and use the same arguments as that former work; but the present discussions and adverse criticism are more elaborate, with large polemic additions, brushing aside and toppling down, according to the author's opinion, all the ingenious devices by which the followers of Agassiz have sought to account for the climatic conditions of their Glacial period.

In opposition to the epeirogenic theory, which seems to the reviewer to be true and sufficient to explain the accumulation of

Pleistocene ice sheets, Sir Henry refuses its most important evidence and support by his denial that the fjords are valleys of river erosion. To his mind the great depths of the fjords beneath the sea level are not a proof of former high land elevation, because he regards these very deep meandering and branching valleys as fissures produced by rock fracture! But geologists can not give credence to this view of the origin of fjords, nor can they go back a century to the diluvial theory of the origin of till, moraines, and glacial striation. W. U.

The Rocks of Tristan d'Acunha, brought back by H. M. S. 'Odin', 1904, with their Bearing on the Question of the Permanence of Ocean Basins. By PROF. ERNEST H. L. SCHWARZ, Rhodes University College, Grahamstown, South Africa. Transactions of the South African Philosophical Society, vol. xvi, pp. 9-51, with two maps and a section; May, 1905.

It is held by this author, following Judd and Suess, that the interior of the earth is composed of a heavy metallic center and is covered by an envelope of siliceous slag. Where volcanic action reaches up from very great depths, it would therefore be expected to bring great masses of metallic substances, like the nickeliferous iron of Ovifak in Greenland. But in no instance has an oceanic island of volcanic rocks yielded a mine of any metal. Nearly everywhere the seat of volcanic upflow appears to be of relatively small depth, where the motion and friction of bending and shearing along great fissure lines have melted parts of the sedimentary or older crystalline rocks of the earth crust.

On the lofty island of Tristan d' Acunha, and on numerous other lone volcanic islands of the South Atlantic, fragments of granite, gneiss, or other rocks of continental types, have been found, leading to the hypothesis that formerly a continental land mass occupied that area, which is now enveloped by profound oceanic waters. The ancient land is supposed to have reached from Cape San Roque to Sierra Leone, on the north, and from southern Brazil through Tristan d' Acunha, to the Cape of Good Hope, on the south; and it is conjectured to have existed from Devonian to Late Tertiary times. W. U.

Geological Survey of New Jersey, Annual Report for the Year 1904. HENRY B. KUMMEL State Geologist. Pages ix, 317; with 19 plates and 18 figures in the text. Trenton, N. J., 1905.

Besides his administrative report, the state geologist writes of the molding sands and the mining industry. The production of iron ore from the New Jersey mines in 1904 was nearly half a million tons, being greater than in any former year since 1891; and the zinc ore production was 250,025 tons.

Dr. Charles R. Eastman presents a report on the Triassic fishes of New Jersey, noting sixteen species.

Stuart Weller describes the fauna of the Cliffwood clays in the Raritan formation, and classifies the Upper Cretaceous formations and faunas of the state.

F. B. Peck treats of the talc deposits of Phillipsburg, N. J., and Easton, Pa.; and Arthur C. Spencer reports the progress of work in the Pre-Cambrian rocks. W. U.

The Geology of the Perry Basin in Southeastern Maine. By GEORGE OTIS SMITH and DAVID WHITE. U. S. Geol. Survey, Professional Paper No. 35. Pages 107, with 6 plates. 1905.

The earliest report of Dr. Charles T. Jackson on the geology of Maine, in 1837, recommended boring for discovery of coal in the sandstone formation bordering the west side of Passamaquoddy bay, in the vicinity of Perry, that formation being supposed to be a continuation of the bituminous coal series of New Brunswick. Later, on the evidence of fossil plants, the Perry beds were regarded by W. B. Rogers, Newberry, C. H. Hitchcock, J. W. Dawson, and others, as of upper Devonian age, being thus older than any known rocks containing commercially workable coal. But citizens of that district, deeming the question yet undecided, petitioned the state legislature two years ago for an appropriation to be expended in drilling for coal, which led to the special survey reported in this paper.

The Perry formation is found to comprise, in ascending order, a lower conglomerate, a lower lava, an upper sandstone, and an upper lava. There has been no very marked folding and but slight alteration of the beds; and their age is shown to be distinctly upper Devonian, and probably Chemung. It is certain that they contain no workable coal deposits. W. U.

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PERSONAL AND SCIENTIFIC NEWS.

PROF. RIES OF CORNELL UNINERSITY has been engaged during the summer, on an investigation of the clays and molding sands of the Virginia coastal plain.

W. T. McCOURT, INSTRUCTOR IN ECONOMIC GEOLOGY in Cornell university, has been studying the peat deposits of New Jersey for the N. J. Geol. Survey.

MR. H FOSTER BAIN is engaged in a study of the Rocky mountain zinc fields for the U. S. Geol. Survey. He will visit Colorado, New Mexico and other producing territories to arrange for the collection of statistics of production for the Division of Mineral Resources.

PROFESSOR T. C. CHAMBERLIN has been appointed a member of the Illinois Geological Survey Board. The remaining members are ex-officio, governor Deneen and president James of the State university.

MR. BAILEY WILLIS returned in July from Europe where he had been since February working under a grant from the Carnegie Institution.

DR. C. W. HAYES of the U. S. Geological Survey spent July and August in Utah and other western states inspecting field work.

PROF EDWARD ORTON JR, State Geologist of Ohio, spent three weeks in July studying the glacial geology of Longs Peak, Colorado. The remainder of the summer he will spend in Massachusetts engaged in editing one of the bulletins of the state survey. Field work for the Geological Survey of Ohio is being carried on by other members of the survey. Prof. John A. Bownocker is studying and mapping the Pittsburg coal in eastern Ohio and completing a bulletin on the salt fields and industry of the state. Prof. Charles S. Prosser is studying the Devonian and Carboniferous formations of the state and part of the summer will be spent on his report on the stratigraphical geology of these formations.

DURING THE MONTH OF JULY Mr. M. L. Fuller and F. G. Clapp of the United States geological survey made a reconnaissance trip through Newfoundland and along the coast of Labrador to a point north of Hopedale for the purpose of comparing the glacial features with those of northeastern United States. Several interesting points relating to possible pre-Wisconsin deposits, to the origin of the high terraces and to the recentness of the last glaciation, were brought out. The intention was to go further north, but this was impossible because of the presence of unusually heavy pack ice along the shore from which the vessel was obliged to withdraw after penetrating it for a distance of some ten miles.

Head of Jamesville Channel Looking Northwest. Site of Glacial Cataract.

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. SEPTEMBER, 1905. No. 3.

PLEISTOCENE FEATURES IN THE SYRACUSE REGION.*

By H L. FAIRCHILD, University of Rochester

PLATES VI. AND VII.

The district lying near the city of Syracuse is one of unusual interest to the student of glacial and geographic geology. In addition to the common forms of Glacial drift there are here displayed a remarkable series of stream canons and cataracts cut by the ice-border drainage, and the shore phenomena of Glacial lakes, specially of lake Iroquois.

Moraines are not strongly represented among the drift forms of the region. No heavy or well-defined moraine occurs near the city, although some masses of hummocky drift are to be seen. Most of the drift burden of the ice sheet was here built into drumlins. Valley moraines occur far south of the city, as has been noted in the description of the railroad routes.

Kames, or water-laid or stratified drift in the form of knolls or mounds of gravel and sand, are scattered over the region, and are conspicuous in the southern part of the city and along the valley sides, their structure being well shown in the excavations for building sand.

The remarkable features of the drift known as "drumlins" are excellently shown in and around the city. The city lies in the eastern end of the belt of drumlins, perhaps the most remarkable in the world, which extends west for a hundred miles. Every hill between Syracuse and Rochester is a drumlin; adthough some of them have a base or core of Salina shale.

* Prepared for the field programme of the meeting of Section E. Am. Assoc. Adv. Sci., Syracuse, N. Y., July 19-22, 1905.

South of the palallel of Syracuse, which lies at the line of the north-facing escarpment of the Onondaga limestone, the ancient valleys that were cut by north-flowing streams are very prominent, the country being a series of north and south valleys and intervalley ridges, a part of the "finger lakes" area. North of the parallel of Syracuse, and where the strata are mostly a great thickness of soft Salina, Niagara and Medina shales, the valleys have been obliterated, partly by the drift filling, and possibly to some extent by the removal by the ice of the saliences in the soft Salina. The city lies in the northern end of the visible Onondaga valley, on a plain produced by Glacial and lake filling. Deep borings for salt show a great depth of valley filling, but the topography of the buried valley can only be determined by systematic borings. In the deeply buried sands of the valley the brines accumulate from the adjacent salt beds, making Syracuse the "saline city."

During the recession of the continental glacier from this region, the ice sheet acted as a barrier to the northward drainage by blocking the northern ends of the valleys. In consequence, lakes were held in all the valleys extending southward into the highland. The earliest and highest waters in each valley found escape southward across the col at the present valley head; but later, as the ice front gave way, the overflow was across the intervalley ridges past the ice border. The evidences of these ancient waters are the deltas built at various levels by the tributary streams, and the outlet channels which determined the several levels. Some of these channels and correlating deltas are very prominent features.

The description and naming of the local lakes in the valleys of the Syracuse region may be found in pages 52-63 of the article noted in the list of references as No. 1. As this may not be available to all readers, a brief enumeration of these lakes is given as follows: In the Otisco valley the primitive and highest water, called the Glacial lake Otisco, had its outlet southward over the col. The lower water, the Mariette lake, escaped west to the Skaneateles valley. In the Onondaga valley the highest water was the Cardiff lake, which had its outlet south through the Tully lakes. Later,

the waters fell to the hight of the outlets at Joshua and Navarino, leading west to the Otisco valley, and are called the South Onondaga lake. A yet lower lake, the Onondaga Valley lake, had eastward escape by the channels at Jamesville. On the Butternut valley the highest lake, Butternut lake, overflowed south across the col and through Tully village, while its successor, the Jamesville lake, had outlet eastward by the channels northeast of Jamesville.

The vast expanse of Glacial waters which were held by the waning ice sheet in the Huron, Erie and Ontario basins had their lower escape through the lower members of the local lakes already mentioned. These were the great lake Warren and the lowering waters, of which only one pause had been determined, namely: lake Dana. The Warren waters reached this territory with an altitude of about 890 feet as the present level. The Dana waters were about 180 feet lower, and the outlet of lake Dana is believed to be the great channel leading east from Marcellus. The numerals given in connection with the channels shown in the accompanying map, show the present altitude of the heads of the channels. (Plate vii.)

The successor of the Warren water and the falling Warren (Hyper-Iroquois) in the Ontario is lake Iroquois, with its outlet at Rome over the Mohawk valley. Lake Iroquois flooded the Syracuse plain and the lower ends of the Onondaga, Butternut and Limestone valleys. The wave-cut notches on the drumlins and the wave-built spits and bars are to be seen near the city.

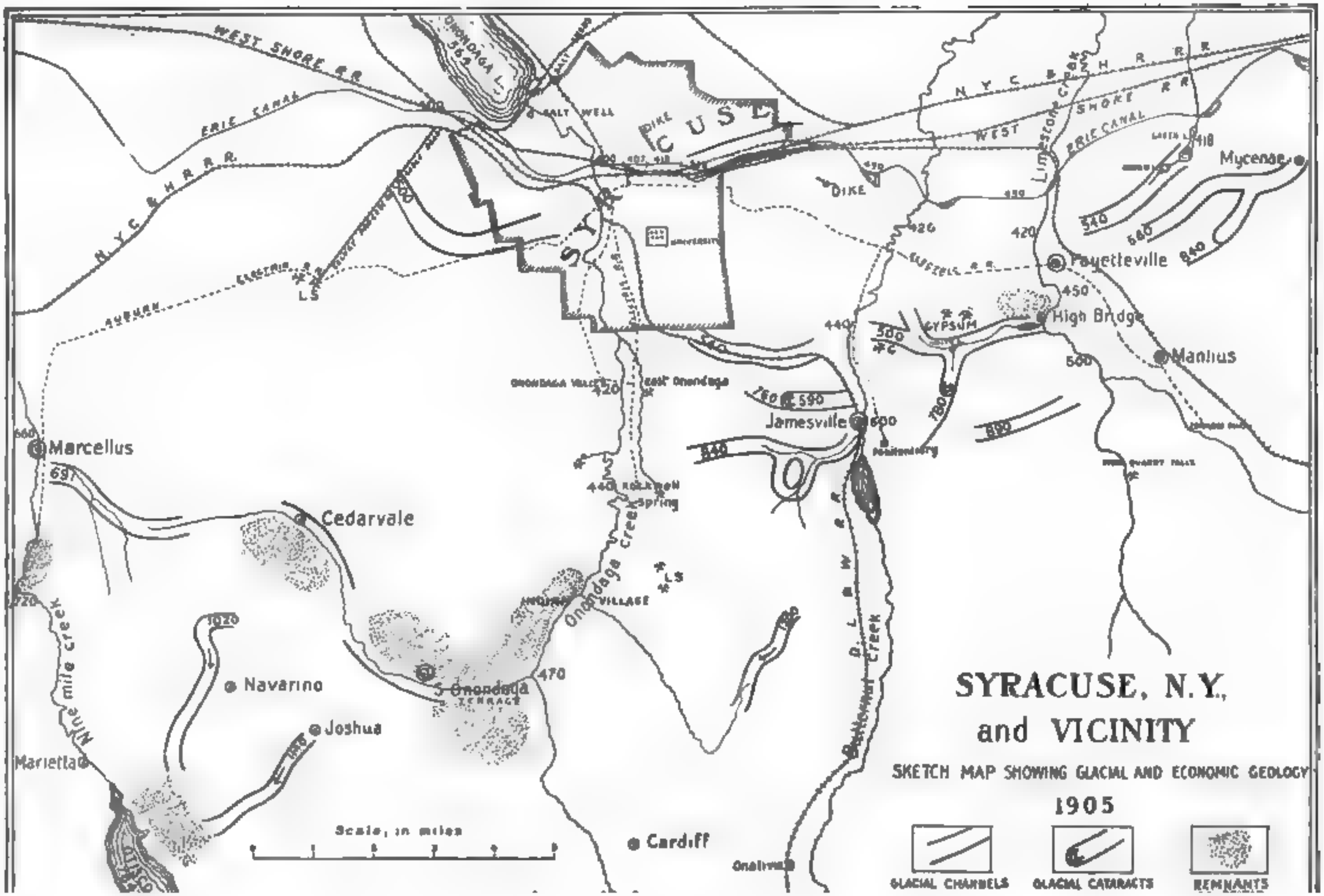
The most novel and interesting features of the region are the deserted river channels, which were cut by the Glacial waters in their escape to the eastward past the ice border. After the glacier had dumped its rock-rubbish in the valleys and so formed the valley-head moraine, or present water parting, it wasted away until the ice border was many miles north of the moraines, thus forming the valley basins that held the local Glacial lakes described above, the northern barrier being the ice body itself. The later waters held in these basins escaped across the ridges and produced the fossil channels that are indicated in the map. The reader should clearly understand that the present

north-flowing streams are in deep and wide pre-Glacial valleys (these are shown by the topographic sheets), while the extinct channels are cut across the tops of the inter-valley ridges and high above the north-south valleys. In other words, the highest of them have both ends in the air. As the crests of the ridges decline or fall away to the north, the transverse channels on any meridian were cut successively from south to north, as the ice barrier receded, and of course at successively lower levels. As no channel was deserted until a lower escape was opened. it follows that each successive or lower channel must have been initiated at an altitude below the bottom of the preceding channel.

The Syracuse channels and cataracts were functionally the predecessors of Niagara, as they carried the overflow of western waters eastward to the Ontarian level. Two of the fossil cataracts, those of Jamesville and Blue lakes, are comparable in hight and capacity to the present Niagara. No visitor, standing for the first time on the crest of the Jamesville lake amphitheater and appreciating the romantic history involved in the phenomena, will regret a journey of a thousand miles to view the region. (See plate vi.

A brief description of these features, with illustrations, may be found in No. 3 of the references.

The rivers which excavated the cross-ridge channels dumped their detritus into the valley lakes. A very prominent delta lies two miles south of Marcellus, in the Otisco valley, but this is beyond the easy reach of the excursions. It may be seen on the Skaneateles sheet. The largest delta in the region is in the Onondaga valley at the junction of the Marcellus-Cedarvale channel, and shows on the Tully sheet. It can be reached on the trips and can be plainly seen miles away, from the east side of the Onondaga valley. This great delta extends from a mile northwest of South Onondaga around the north of Indian Village, a stretch of four miles. Another delta lies west of Jamesville at the mouth of the gorge, below the lake and ancient cataract. Still another and more conspicuous delta occurs at High Bridge in the limestone valley at the mouth of the White lake channel, and is mapped in the southeast corner of the Syracuse sheet. Small terraces and benches of stream detri-


SYRACUSE, N.Y.
and VICINITY
SKETCH MAP SHOWING GLACIAL AND ECONOMIC GEOLOGY
1905
GLACIAL CHANNELS
GLACIAL CATARACTS
REMNANTS
Scale, in miles
ONONDAGA L.
WEST SHORE R.R.
ERIE CANAL
N.Y.C. & H.R.R.R.
SALT WELL
DIKE
Limestone Creek
Mycenae
Fayetteville
High Bridge
Manlius
GYPSUM
Jamesville
Onondaga Creek
Butternut Creek
Marcellus
Cedarvale
Navarino
Joshua
Onondaga
TERRACE
Marietta
Nine mile creek
Cardiff
Onativia
VILLAGE
Spring

tus, built in the Glacial waters, may be seen along the slopes of the valleys, correlating with the lake levels established by the stronger channels. Those in the Onondaga valley are more specially related to the Railroad channel.

REFERENCES.

1. Bulletin Geol. Soc. Am., x: 57-66.
   Gives a description of the Glacial lakes, with illustrations.
2. Amer. Jour. Sci., vii: 249-263.
   Describes the Glacial lakes Newberry, Warren and Dana.
3. 20th Ann. Rep. N. Y. State Geologist, 1900, pp. 112-129.
   Describes and illustrates the extinct channels and cataracts in the Syracuse region.
4. 21st Ann. Rep. N. Y. State Geologist, 1901, pp. 33-47.
   Describes and illustrates the lower channels between Syracuse and Rome, especially the channel which passes through the city of Syracuse.
5. 22nd Ann. Rep. N. Y. State Geologist, 1902, plate 1, facing p. 19.
   Map with description of lake Warren.
6. Bulletin Geol. Soc. Am., ix: 173-182.
   Description by E. C. Quereau of the Jamesville lake and surroundings.

CAR-WINDOW GEOLOGY: SUGGESTIONS TO TRAVELERS.

Approaching Syracuse from the west by the New York Central or the West Shore railroad,—From Buffalo to Crittenden the New York Central R. R. lies on the leveled lake-bottom of Warren waters, the strong beach of which is crossed at Crittenden. From there to beyond Batavia the road is in the well-accentuated Batavia moraine. From there to Rochester the generally smooth plain is diversified with drumlins and low kames. The West Shore road lies on the Warren lake-bottom nearly all the way, and at Smithville station a conspicuous cliff cut by Warren waves may be seen on the south. From Oakfield to Rochester scattered drumlins may be seen on the south. From Oakfield to Rochester scattered drumlins may be seen on the south, with moraine topography at Churchville.

From Fairport (east of Rochester) to and beyond Syracuse these railroads follow the river channels cut by the Glacial waters in their eastward flow. From Newark eastward the work of lake Iroquois waves may be seen in numerous notches or terraces on the drumlins, at from 20 to 30 feet above the level of the railroads. For the whole

distance the drumlins appear in remarkable form. The Salina shales appear in places as red or green clay-like exposures, the best display being 3 miles east of Newark, on the south side of the tracks.

Approaching Syracuse from the east by the New York Central.—From Schenectady to Rome the railroad lies in the ancient channel of the Iromohawk river, a stream larger than the St. Lawrence, which carried the overflow of the Glacial lake, lake Iroquois. On the south wall of the valley may be seen the high-level channels cut by Glacial waters when held up by the ice front. Such are conspicuous three or four miles west of Little Falls and east of Utica for several miles. Between Little Falls and Rome the deltas built in the earlier waters and the flood plains of the Iromohawk are conspicuous. (This stretch is covered by the Utica, Oriskany and Oneida sheets of the geological map of New York State.) From Rome to near Oneida the railroad lies in a pronounced Glacial river channel. All the way from Oneida to Syracuse the tracks lie on the Iroquois lake-bottom, while the south banks of the ice-border drainage are conspicuous at many points, on the south side of the train appearing as steep bluffs on the saliences. The north bank of the stream was the ice of the ancient Glacial cap.

The West Shore railroad parallels the New York Central from Oneida to Syracuse and shows the stream-cut bluffs even better, since it lies farther south.

Approaching Syracuse from the south by the Delaware Lackawanna and Western railroad.—Northward from Binghamton the road follows valleys which were the southern escape of Glacial waters. The abundant stream detritus may be seen in the broad stretches of gravel plains and in terraces and deltas at the mouths of side valleys. From Tully northward for two miles the road lies in the small channel across the col which was the outlet of the Butternut Glacial lake. From Apulia to Jamesville the road lies high on the west side of the Butternut valley and commands a fine view of the valley features. For three miles north of Apulia the valley is partly filled with moraine drift. Opposite Onativia broad delta terraces are seen on the east side, which correlate with the Tully outlet. Moraine drift is

conspicuous, either in the valley bottom or banked against the walls. (The Tully sheet covers all this area.)

Between Jamesville and Syracuse the road passes through the grandest of the ancient river channels, the "Railroad" channel, which is a fourth of a mile wide and 150 feet deep, mostly in Onondaga limestone. (Syracuse sheet.)

Approaching Syracuse from the North —The two branches of the Rome, Watertown and Ogdensburg railroad, and the Oswego division of the Delaware, Lackawanna and Western railroad leading into Syracuse from the north, all lie on the Iroquois lake-bottom but encounter few striking features, though all the ordinary forms of drift appear. At the junction of the two branches of the Rome, Watertown and Ogdensburg at Woodward, the railroad cuts across a heavy ridge or bar of lake Iroquois (Syracuse sheet). From Adams Center south to Richland Junction, more than 20 miles, the R., W. & O. lies on the west (lakeward) side of the heavy Iroquois beach, carrying a "ridge road." (Pulaski, Sacketts Harbor and Watertown sheets.)

Approaching Syracuse from the west by the Auburn branch of the New York Central railroad—At Victor this line is in a great channel of Glacial flow, which it again traverses from Clifton Springs through Phelps to near Geneva. At Halfway Station it enters another striking channel, which it follows through Camillus to near Syracuse. This is on the Baldwinsville sheet.

NOTES ON THE PERMIAN FORMATIONS OF KANSAS.

By Charles S. Prosser, Columbus, Ohio.

In 1902 the writer reviewed the recent literature regarding the correlation of the upper Paleozoic of Kansas with the Russian Permian.* In this review the writer inadvertently omitted reference to the papers of Dr. E. H. Sellards identifying and describing Permian plants from Kansas, although he was familiar with them. In 1900 Dr. Sellards reported the identification of *Callipteris conferta* Sterng. from the Marion formation (or possibly the lower part of the Wellington shales) of Dickinson county in eastern central Kansas and the geological importance of this discovery was discussed as follows by him:

"The geological range of *Callipteris conferta* has an interesting bearing on the question of the age of the uppermost Paleozoic rocks of Kansas. The species is characteristic of the middle and lower Rothliegenden of Europe, but has not been found above the middle of the Permian. It has also been found in the Permo-carboniferous of West Virginia. The occurrence of this species near the top of the Kansas strata [in Dickinson county only the Big Blue series or lower Permian occurs; the Cimarron series or upper Permian is found farther south] together with *Sphenophyllum*, a genus that has not been discovered above the middle of the Permian, makes it improbable that the Kansas beds are younger than middle Permian. While, on the other hand, the presence of *Callipteris*, a Permian genus, and the number and variety of plants belonging to the Tæniopteroid group, as well as the general character of the flora, tends to confirm the Permian age of the Kansas Upper Paleozoic."†

In 1900 fossil plants were found in the Smoky Hill river valley just east of Salina in Saline county, which adjoins Dickinson county on the west, in rocks of about the same age as those of the former locality. In commenting upon the plants from both of these localities Dr. Sellards said:

"There are, in the collections so far made, some twenty-six or twenty-seven determinable species, distributed in fourteen genera. The plants indicate unmistakably the true Permian age of the formation in which they are found. Many of the species are characteristically Permian, and only a very small proportion of the species identical with Upper Carboniferous species."*

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* Jour. Geol., vol. x, pp. 721-737.
† Bull. Univ. Kansas, vol. 1, No. 2 (Kan. Univ. Quarterly, vol. ix, No. 1), p. 84.
* Trans. Kansas Acad. Sci., vol. xvii, 1901, p. 209.

Part of this flora has been described by Dr. Sellards† and in the second paper he identifies and describes *Tæniopteris coriacea* Goep. which he states:

"Seems to have been found as yet in only two other localities, both Permian, Ottendorf in Bohemia, and Lissitz in Moravia."‡

In 1903 Dr. Keyes published a paper entitled "Some recent aspects of the Permian question in America,"† in which he objected to certain statements in my article of the previous year. His principal objection, apparently, was that in giving the "Classification of the upper Paleozoic formations of Kansas" the writer used Cragin's name of Big Blue instead of Keyes' term Oklahoman for the lower series of the Permian and stated that in Kansas they were identical. The following brief history of these two terms will furnish a basis for judging whether it was a fair statement or not. The term "Big Blue series" was proposed by professor Cragin in March, 1896, for the lower Kansas Permian formations‡ which he listed as follows:

Wellington shales.
Geuda salt-measures [which later he withdrew in favor of the name Marion formation]*
Chase limestones.
Neosho shales.†

Professor Cragin stated that

"It may be called the Big Blue series, from the Big Blue river, which in northern Kansas crosses the somewhat narrowed northern extension of its area of outcrop."‡

The upper Permian formations, popularly termed the Red Beds, were named the Cimarron series by professor Cragin in the same article.§

In July, 1896, Dr. Keyes proposed "to recognize in the 'upper' Carboniferous of the western interior province three series having equal taxonomic rank," the upper two of which in ascending order were named the Missourian and Oklahoman.* The top of the Cottonwood limestone was

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† Bull. Univ. Kansas, vol. i, No. 4 (Kan. Univ. Quarterly, vol. ix, No. 3), 1900, p. 179 and *ibid.* vol. ii, No. 1, (Kan. Univ. Quart., vol. x, No. 1), 1901, p. 1.

* *Loc. cit.*, p. 3.

† Am. Geol., vol. xxxii, p. 218.

‡ Col. Coll. Studies, vol. vi, March 27, pp. 3, 5, 6.

* Am. Geol., vol. xviii, Aug., 1896 p. 132.

† Col. Coll. Studies, vol. vi, p. 3.

‡ *Ibid.*, p. 6.

§ *Loc. cit.*, pp. 3, 18, 48; see additional account in Am. Geol., vol. xix, May, 1897, pp. 351-364.

* Am. Geol., vol. xviii, p. 25.

given as the upper limit of the Missourian series and in defining the series it was stated that

"In suggesting the name Oklahoman as a serial geological term it is intended to apply to all those rocks of Carboniferous age which occur north of the Canadian river in Oklahoma and which lie between the interval of the top of the Missourian series and the base of the Cretaceous. It may be regarded as essentially covering the same succession of strata that has long been vaguely known under the title of 'Permian.' The name is derived from the territory in which the formation has its best development and in which the most complete sequence is represented. The best sections across the belt appear to be exhibited along the Cimarron, Arkansas and Kansas rivers, and these sections may be considered typical."[*]

In October, 1901, Dr. Keyes accepted the name Cimarron series for the Red Beds[†] and gave the upper three series of the Carboniferous in ascending order as the Missourian, Oklahoman and Cimarron[‡] stating their respective stratigraphic values as 4, 2 and 1.[§]

The following month Dr. Keyes published a "General Geological Section of the Carboniferous of the Mississippi Valley," in which a complete list of the series and terranes of the system is given. For the portion under consideration it is as follows:

	Series.	Terranes.
Carboniferous system. [Upper portion]	Cimarron.....	Kiger shales. Salt Fork shales.
	Oklahoman....	Wellington shales. Marion limestone. Chase limestone. Neosho shales.
	Missourian [Upper part]	Cottonwood limestone. Atchison shales. [Wabaunsee of Prosser][*]

It will be seen from the above quotation that the terranes listed by Dr. Keyes as composing the Oklahoman series are entirely Kansas formations and precisely the same as those given by professor Cragin for the Big Blue series. It was this agreement which led the writer in his "Classifi-

[*] *Ibid.*, p. 27.
[†] Am. Jour. Sci., 4th ser., vol. xii, p. 309.
[‡] *Ibid.*, pp. 306, 309.
[§] *Ibid.*, p. 306.
[*] Am. Geol. vol. xxviii, Nov., 1901, p. 302.

cation of the upper Paleozoic formations of Kansas" to state that

"It will be seen that the Oklahoman series, as precisely defined above, is identified with the Big Blue series proposed by Dr. Cragin in 1896, and therefore his name, which has priority, is adopted for this classification."†

Dr. Keyes in discussing my paper has objected to the above interpretation and made certain statements regarding the limits of the Oklahoman series. He says: "When the title Oklahoman was first proposed for the uppermost series of the Carboniferous its upper limits were not very definitely fixed—further than it was stated that in a general way the terrane corresponded to what had previously been called Permian. At that time the Red Beds were regarded as post-Carboniferous in age."‡

The original statement of Dr. Keyes in 1896, when he first defined the Oklahoman series is as follows:

"In suggesting the name Oklahoman as a serial geological term it is intended to apply to all those rocks of Carboniferous age which occur north of the Canadian river in Oklahoma and which lie between the interval of the top of the Missourian series and the base of the Cretaceous. * * * Although there has been little detailed study in the region regarding the relations of the series under consideration and the Cretaceous above, it is well known that the latter rests in marked unconformity upon all four series of the Carboniferous and at the north extends over still older formations."*

The writer has given a fairly complete historical review of the correlation of the Red Beds or Cimarron series of Kansas† and the following brief statement of the most important changes in their correlation will be of interest in connection with the above quotation. In early papers the Red Beds were frequently called Cretaceous and correlated with the Dakota sandstone. In 1887 professor St. John referred them with a query to the Triassic system.‡ For several years subsequent to this report the age of the Red Beds was generally given as either Triassic or Jura-Trias. In 1893, however, professor Hay changed his correlation of the Red Beds of Kansas to the Upper Permian on account of the discovery of Permian fossils in Texas in beds which he considered as of similar age.*

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† Jour. Geol., vol. x. 1902. chart opposite p. 718.
‡ Am. Geol., vol. xxxii, Oct., 1903, p. 219.
* Am. Geol., vol. xviii, p. 27.
† Univ. Geol. Surv. Kansas, vol. ii, 1897, pp. 75-83.
‡ Fifth Bien. Rept. Kansas State Board Agr., pt. ii, pp. 140, 141.
* Eighth *ibid.*, pt. ii, pp. 101, 108.

In March, 1896, professor Cragin named the Red Beds of Kansas, the Cimarron series, published a detailed account of it, which he unhesitatingly referred to the Permian system, and subdivided it into ten formations.‡ It will thus be seen that for some years previous to the proposal of the Oklahoman series by Dr. Keyes in July, 1896, the Red Beds of Kansas had generally been considered by geologists as belonging in the Jura-Trias, the Triassic or the Permian. It is also evident from Dr. Keyes' original definition of Oklahoman that for part of the territory he had in mind for its upper limit the base of the true Cretaceous, so that it was an open question whether he intended or not to include in it the Red Beds. It is interesting to note in this connection that in November, 1904, in a "Generalized geological section for New Mexico" Dr. Keyes gave the age of the "Cimarron formation" as Triassic* although Dr. Beede more than three years before had shown conclusively from fossils that in its typical area the greater part of the Cimarron series is of Paleozoic age.†

Dr. Keyes in his paper of 1903 indicates the limits of the Oklahoman series in the following manner:

"As it now appears, even according to professor Prosser's published data, the Oklahoman in central Kansas includes at the base at least one important formation more than the Big Blue series; and at the top at least one formation less. The Oklahoman series in Kansas is delimited above by the top of the Marion limestones. In my various papers, with one exception due to a typographical error arising from inability to see the proof sheets of the article, this fact is clearly indicated. This is particularly emphasized in the memoir frequently quoted by professor Prosser, on the detailed comparison of the Upper Carboniferous of Kansas with the Russian Permian."*

It has already been shown that the basal formation of the Oklahoman series as defined by Dr. Keyes is the Neosho shale,† which is also the lowest formation of the Big Blue series as defined by Dr. Cragin.‡ It is, therefore, clear that the basal limit of the Oklahoman and Big Blue series as de-

‡ Col. Coll. Studies, vol. vi, pp. 1-5, 48.
* Am. Jour. Sci., 4th ser., vol. xviii, p. 360.
† Jour. Geol., vol. ix, July, 1901, p. 339.
Am. Geol., vol. xxviii, July, 1901, pp. 46, 47.
Adv. Bull. First Bien. Rept. Oklahoma Geol. Surv., April, 1902, pp. 1-11.
* Am. Geol., vol. xxxii, pp. 219, 220.
† Am. Geol., vol. xxviii, 1901, p. 302.
‡ Col. Coll. Studies, vol. vi, 1896, p. 3.

fined by their respective authors is the same. This is not changed by the fact that in my paper of 1902 the Neosho shales were made the upper division of the Missourian rather than the lower division of the Big Blue series.

Dr. Keyes in 1903 clearly states that the top of the Oklahoman series is marked by the top of the Marion limestones and apparently states that the inclusion of the Wellington shales in it in November, 1901, was due to a typographical error.§ The paper just cited gave no evidence of such error and at the time of the publication of my classification in 1902 Dr. Keyes had made no statement which clearly indicated such error. The paper cited as the one in which Dr. Keyes "particularly emphasized" this line is apparently the one on the "American homotaxial equivalents of the original Permian."* In this article there are two portions which bear upon the point in question. First, Dr. Keyes gave a table entitled "Comparison of general sections" in Russia and the Mississippi valley which is as follows for the upper Paleozoic rocks:

Russia.	Character of Terranes.	Mississippi Valley.	
Tartaran, Permo-Trias, or Upper Permian, P^3	Shales and marls, red and variegated, shaly sandstones; fossils rare; "Red Beds."	Cimarron Series.	
Middle Permian, P^2....	Limestones, some dolomitic, separated by calcareous marl	(Marion li.)	Series.
Lower Permian Pl—b..	Shales (only 200 feet thick in Kama Valley.)	————?	
Upper Permo-Carboniferous (base of original Permian) C Pc.	Limestone, heavy dolomitic.	(Chase li.)	
Artinsk, C P....	Shales, sandstones, some thin limestones.	(Neosho) (Cottonwood) (Wabaunsee)	Series.
Upper Carboniferous, C^3.......	Limestones and shales, highly fossiliferous.	Missourian Series.	

§ Am. Geol., vol. xxviii, p. 302.
* Jour. Geol., vol. vii, 1899, pp. 321-342.
* *Ibid.*, p. 332.

The second paragraph of this division of the paper treating of the classification of this part of the rocks is as follows:

"The uppermost division of the Paleozoic of the region, the part widely designated as the 'Red Beds,' has received the title of Cimarron series. It appears to form a tolerably compact sequence, though there is still some dispute as to its exact geological age. Between the Cimarron series and the Missourian series are two other terranes that are well defined. One is composed of the Chase and Marion of Prosser, in part, and the other of the Wabaunsee, Cottonwood, and Neosho."*

It will be seen from the above quotations that it is not definitely stated that the Wellington shales are put in the Cimarron series. Again, the name Oklahoman series does not appear in the paper; the top of the Missourian series is drawn from 500 to 550 feet lower than in his former papers and the rocks between the Missourian, as there limited, and Cimarron series are divided into two series which are not named and clearly neither one nor both together agreed with the Oklahoman series as previously defined. The writer attempted to represent the views of Dr. Keyes fairly and, if he failed, it appears to him that it was partly due to the lack of clearness in the statements made by Dr. Keyes.

The writer, however, objects to the last paragraph of Dr. Keyes' paper which is not a fair statement. It is as follows:

"A singular argument does professor Prosser use to retain the title of Permian as the name of a system and period. He refers to half a dozen Russian writers who have used the title in this sense. No allusion whatever is made to a much larger number of Russian geologists who are equally distinguished and who all have worked extensively in the typical regions, but who hold very different views. This method of presentation is hardly the scientific method."*

As a matter of fact the writer took the later official reports of the Russian survey† so far as he was able to obtain them, and gave a very condensed but impartial statement regarding the classification of the rocks under consideration.

* *Loc. cit.*, p. 339.

* Am. Geol., vol. xxxii, p. [illegible].

† In obtaining references to various articles in the *Mémoires du Comité géologique de Saint Pétersbourg* describing the upper Paleozoic the writer availed himself of the copious foot notes in volume II of Suess' "La face de la terre" Margerie's translation, 1900, and references in Frech's "Lethaea palaeozoica."

There was no change, selection or elimination and if it favored the views which the writer expressed, such was the concensus of the evidence before him. At that time, however, the writer inadvertently overlooked the following statement of Nikitin, the well-known Russian authority on the Carboniferous: Finally the Americans, as is known, generally refer, contrary to European geologists, the so-called Permo-Carboniferous of Mr. Meek to the Carboniferous system.*

Regarding the correlation with and retention of the name Permian for the upper American Paleozoic deposits the writer in 1902 made the following statement:

"The number of American geologists who believe that these Upper Paleozoic formations should be correlated with the Permian and given the rank of a period or system is probably still smaller than the number of those who would retain the name Permian but classify it as the upper series of the Carboniferous. * * * It has appeared to me, however, that the weight of evidence favored correlating the upper formations with the Permian."†

Since the publication of the above paper additional evidence favoring the correlation of the upper Paleozoic deposits of Kansas with the Permian has been received. The following brief summary will give an idea of its nature:

In January, 1903, Dr. Sellards wrote me as follows:

"The fossil plants in my opinion support your belief in the existence of true Permian in Kansas (below the Red Beds). The flora of the Marion (or Wellington) differs specifically almost *in toto* from that of formations as low down as the Lawrence shales [which occur near the middle of the Missourian series of Dr. Keyes and form the lower member of professor Haworth's Douglas formation] and indicates as I have already stated (Kan. Acad. Sci., 1900; Kan. Univ. Bull., vol. 9, Jan., 1900) a lower Permian age. The plants in this case are pretty conclusive and the genera and species are identical with or most closely related to those of the lower Permian of Europe."*

Dr. Sellards has also found insects exceptionally well preserved in the Marion formation in the southern part of Dickinson county. He also states that

"A considerable number of insects had been previously obtained from the Coal Measures near Lawrence, Kansas"

and he contrasts these two insect faunas as follows:

* Mém. Comité Géologique, vol. v, No. 5, 1890, p. 152.
† Jour. Geol., vol. x, p. 728.
* Letter of Jan. 12, 1903.

"The insects from the Marion seem on the whole very different from those of the Lawrence shales and other Coal Measure deposits. The Coal Measure insects, as far as known, are on the average large; on the contrary, most of the Marion species are small. Cockroaches at this new locality are much in the minority. Of some six hundred specimens collected, not more than about sixteen are cockroaches and these are of small size and belong for the most part to the Coal Measure and Permian genus, *Etoblattina* Fossil plants were discovered in the Marion in 1899. The collections made from the Marion and Wellington (?) during 1899-1900 seemed to the writer at that time to indicate a lower Permian flora. These collections have since been increased, and it may now be said with a good deal of confidence that, although a few species have survived from the Upper Coal Measures, the Marion contains on the whole a distinctly Permian flora. The marked change in the insect fauna in passing from the Lawrence shales to the Marion formation is therefore paralleled by the plant evolution."†

The evidence furnished by fossil plants regarding the correlation of the upper Paleozoic formations of Kansas has been reviewed by Dr. David White. His conclusions concerning two of these floras are important in reference to the identification of the Permian. The lower of these floras is from the Elmdale formation (which in the writer's classification is put in the Wabaunsee stage of the Missourian series, beginning about 200 feet below its top) at Onaga, in the northeastern part of Pottawatomie county and part of its analysis by Dr. White follows:

"No species in any way characteristic of the Lower Coal Measures or the Allegheny formation remains. On the other hand, the ferns, either as individual species or as phases of species having wide range, are clearly indicative of a stage at least very high in the Upper Carboniferous (Pennsylvanian). Nearly all the species have been reported from either the Permian of Europe or the Dunkard formation of the United States, though, with the possible exception of *Pecopteris Newberriana*, none are distinctly characteristic of the Permian. Most of the forms present occur in the Dunkard formation, whose flora was fully treated by professors Fontaine and I. C. White. * * *

"The evidence presented by this small Onaga flora may, therefore, be construed, so far as it represents the plants of its horizon, as indicating a stage probably within the Monongahela formation of the Appalachian region, or possibly as high as the lowest part of the Dunkard formation, although, with the exception of *Pecopteris Newberriana*, the collection in hand does not contain

† Am. Jour. Sci., 4th ser., vol. [illegible] 1903, pp. 323, 324

any species characteristic of the Permian of the old World, and does not signify a Permian age for the Onaga (Elmdale) beds."*

The importance of the above reference to the Dunkard formation will be appreciated when it is recalled that in 1880 professors William M. Fontaine and I. C. White described the flora of the Upper Barren Coal Measures (now called the Dunkard formation) of West Virginia and southwestern Pennsylvania and in conclusion stated that:

"To sum up finally the evidence derived from all sources, we find ourselves irresistibly impelled to the conclusion, that the * * * Upper Barrens of the Appalachian Coal Fields are of Permian age."†

The fauna of the Dunkard formation is very small and does not afford conclusive evidence as to its age but the flora has been recently re-examined by Dr. David White who corroborates the earlier conclusions of Fontaine and I. C. White. In the lower part of the Dunkard formation is the lower Washington limestone, which at the typical locality at Washington in southwestern Pennsylvania occurs 117 feet above the top of the Waynesburg coal or base of the Dunkard. Dr. David White draws the following conclusions regarding the age of the Dunkard formation:

"It appears that the beds below the Lower Washington limestone can not yet be regarded as conclusively referable to the Rothliegende, though they contain a flora which is certainly transitional. The re-enforcement of this flora at the levels of the Washington and Dunkard coals by the more important and distinctly characteristic Rothliegende species * * * seems to fully justify the reference of the latter to the Rothliegende, the lower boundary of which may probably be drawn as low as the Washington limestone, which is as yet the lowest observed Callipteris horizon. Further search in the floras of the lower beds of the Dunkard and in the Monongahela is necessary before the upper boundary of the Coal Measures can be definitely ascertained. The flora of the upper portion of the Dunkard is to be compared with those of the Stockheim and Cusel beds in Germany and of the series in the basin of the Brives in France. * * * The reference of the greater part of the Dunkard to the Lower Rothliegende appears to be well founded; but it seems to the writer as probable that the plants of the Upper Dunkard or of the lowest of the terranes of western Europe that are now generally classed as Rothliegende are hardly of so late a date as the flora of the Artinsk stage of Russia."*

* U. S. Geol. Surv., Bull. No. 211, Nov., 1903, pp. 115-116.
† Second Geol. Surv. Pa., PP., p. 119.
* Bull. Geol. Soc. Amer., vol. 14, March, 1904, pp. 541, 542.

The Rothliegende is the older division of the Permian of western Europe, which is found typically in Germany. The Artinsk stage in Russia is referred by the eminent Russian geologist Dr. Tschernyschew to the Permo-Carboniferous; but by Dr. Frech and many other European geologists it is considered as lower Permian. A number of European geologists have accepted Permian as the age of the Dunkard formation and Dr. Frech states that the Dunkard creek beds and Cassville plant shale, the latter of which is the shale at the base of the Dunkard formation immediately overlying the Waynesburg coal, are the equivalent of the Cusel stage, which is the oldest division of the Lower Rothliegende of Germany. And in another sentence is the statement that the petrographical and paleontological similarity of the Dunkard with the Rothliegende of western Europe is therefore beyond doubt.* Dr. Kayser also puts the Dunkard in the Permian and he has made the following statement concerning its age:

> In the United States we find in the east (Virginia, Pennsylvania, etc.) in conformable layers upon the Upper Carboniferous the so-called Barren Measures with *Callipteris conferta*, *Taeniopteris* and other Permian characteristic forms together with typical Carboniferous plants as representative of the Permian.*

The youngest of the Kansas floras discussed by Dr. David White is that from Dickinson county which he states Dr. Sellards gives

> "As coming either from the topmost beds of the Marion formation or possibly from the base of the Wellington formation."

Dr. White's conclusions are as follows:

> "I have not had an opportunity to examine the remaining material at the State University [of Kansas], but if the composition of the entire flora proves to be of so young a character as the material described or placed in my hands by Mr. Sellards, his conclusion that the beds are of so late date as the Lower Permian will appear to be fully justified. I am not informed whether any of the gymnospermic species so important in, and so typically characteristic of, the Permian of Europe or Prince Edward island are present in Kansas. However, such pteridophytic material as has come to me for examination is more nearly typical and characteristic of the Permian than any flora that I have yet seen from another formation in the United States.

† Lethaea geognostica, Th. i, Lethaea palaeozoica, Bd 2, Lief 3, 1901, p 646.

* Lehrbuch d. geol Formationskunde, 2d ed., 1902, p. 264.

If the plants preliminarily listed above are representative of the plant life of the Upper Marion or the Wellington formation, the flora of these beds is probably of a date fully as late as the earlier of the floras generally referred to the Permian in western Europe. In any event a flora containing these species can hardly be older than the topmost Carboniferous, or transitional from the Upper Carboniferous to the Permian."*

The last published paper of the late Dr. Charles E. Beecher entitled a "Note on a New Permian Xiphosuran from Kansas" appeared in July, 1904, the horizon of which was given as the Fort Riley limestone (which occurs in the upper half of the Chase stage) and was unhesitatingly correlated with the lower Permian.†

In 1902 the writer stated:

"It is probable, however, that the U. S. Geological Survey will retain the name Permian, but will classify it as the last series of the Carboniferous system."

This is now the official position of the U. S. Geological Survey. The rules of the survey relating to "Nomenclature and Classification for the Geologic Atlas of the United States" were revised during 1902 and 1903 and under the subheading of "Correlation and grouping of sedimentary formations" Rule No. 22 states that:

"The following series are now recognized as applicable to North America; * * * in the Carboniferous, Permian, Pennsylvanian, and Mississippian."*

In numerous recent official reports and papers of the U. S. Geological Survey the upper Paleozoic deposits of the Great Plains are described under the name of the Permian series of the Carboniferous system or period. In fact it now apparently regards the Waynesburg sandstone at the base of the Dunkard formation as of Permian age, since it is so given without question by Mr. Marius R. Campbell in the "Columnar Section" of the Latrobe Folio.* It is also important to note that in nearly all the recent official state and territorial reports, the formations of the general age of those under discussion are described under the name of Permian and classified either as the youngest series of the Carboniferous system or the last system of the Paleozoic.

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* U. S. Geol. Surv., Bull. No. 211, p. 117.
† Am. Jour. Sci., 4th ser., vol. xviii, p. 24.
‡ Jour. Geol., vol. x, p. 728.
* Twenty-fourth An. Rept., Director U. S. Geol. Surv., 1903, p. 27.
* Geol. Atlas of the U. S., Folio No. 110, 1904.

This certainly indicates a marked change in the opinions of American geologists concerning the age of these deposits since the publication of the writer's paper on "The Classification of the Upper Paleozoic rocks of Central Kansas" in 1895.†

In 1891 Dr. Th. Tschernyschew, the able Director of the Russian *Comité Géologique* and the eminent authority on the middle and upper Paleozoic of Russia, attended the Washington meeting of the International Geological Congress and later studied the upper Paleozoic rocks of Kansas as exposed along the Kansas river from Manhattan to Fort Riley. In his monograph on "Die obercarbonischen Brachiopoden des Ural und des Timan" he reviews the description and classification of the upper Paleozoic formations of Kansas and correlates them with the Russian. Tschernyschew's conclusions concerning the correlation of the upper Paleozoic deposits of Kansas with those of Russia are as follows:

> I have become personally acquainted with the strata of the Wabaunsee and Cottonwood during an excursion in the state of Kansas, the former in the railway cut near the Manhattan station; the latter near the same place in Ulrich's quarry. Both I would prefer to put in line with the Cora horizon in eastern and northern Russia. The Neosho strata, and perhaps also the lower part of the Chase, appear analogous to the Russian Schwagerina horizon and the remainder of the latter, as also the Marion, one must regard as homotaxial to the Russian Permo-Carboniferous and lower Permian. Finally, the Wellington and Cimarron necessarily correspond to the lower red colored Permian in eastern and northern Russia.*

The Schwagerina beds form the upper division of the unquestioned upper Carboniferous of Russia, while the Cora beds form the next older division which is characterized by the Brachiopod shell named *Productus cora*. Succeeding the Schwagerina beds is the Artinsk stage of the Russian Permo-Carboniferous which is classified by Drs. Frech and Kayser and many other European geologists as lower Permian. In my "Classification of the Upper Paleozoic formations of Kansas" published in 1902, but a year before a copy of Dr. Tschernyschew's Memoir was received, the provisional line between the Carboniferous and Permian sys-

† Jour. Geol., vol. iii, pp. 682-706, and pp. 764-801.

* Mém. Comité Géologique, vol. xvi, No. 2, 1902, pp. 392, 393, of Russian text, and p. 703 of German text.

tems was drawn at the base of the Wreford limestone or lowest formation of the Chase stage. It will be seen that this correlation agrees very closely with that of Dr. Tschernyschew, since he draws the homotaxial line representing the separation of the Russian upper Carboniferous and Permo-Carboniferous either at the base or in the lower part of the Chase stage.

The following table from Dr. Tschernyschew's Memoir gives his idea regarding the correlation of the Russian and American formations:

Ural and Timan of Russia.	Texas and Arkansas	Kansas, Nebraska, Iowa, Missouri
Artinsk—Ablagerungen..	Wichita and Clear Fork beds.	Marion beds. Chase beds.
Schwagerinen—Horizont.	Albany and Cisco beds	Neosho beds.
Cora—Horizont.	Canyon and Strawn beds	Missourian series and Cottonwood beds of Kansas and Nebraska. Wabaunsee beds, Oread limestone and Osage shales of Kansas.*

Several geologists have in a general way correlated the Wichita division of Texas with the lower Permian of Kansas and professor Cummins has stated that:

"It is quite certain that the Ft. Riley horizon is the same as the Wichita division of Texas, and is at the very top of the division."*

Dr. Kayser puts the Wichita in the Permian and has recently written as follows concerning its correlation:

In the southern and western states (Texas, Kansas, Nebraska, &c) occur directly above and in intimate connection with the marine Upper Carboniferous principally sandy, slaty, chalky strata, the so-called Wichita beds. These contain in their lower division numerous Theriodonts (*Naosaurus*), Stegocephs (*Eryops, Cricotus*) and fishes (*Pleuracanthus, Janassa,* etc.) recognized by Cope long since as Permian; in the upper division besides numerous mostly Carboniferous species (especially of the Brachiopods—*Productus, Marginifera, Camarophoria, Spirifera,* etc.—Lamellibranchs, Gastropods) Permian Ammonites (*Medlicottia, Popanoceras, Waagenoceras*). Above, follows as representative of the upper Permian a predomi-

* *Ibid.* p. 395 of Russian and 706 of German text.

* Trans. Texas Acad. Science, vol. ii, 1897, p. 98. For a summary of the various opinions regarding the correlation of the Kansas and Texas beds see Jour. Geol., vol. x, 1902; pp. 724-727.

nant red colored formation composed of sandstones, clays and shales, gypsum and salt-bearing, unfossiliferous, comparable to the Russian Tartarian stage.*

The Tartarian is the upper stage of the Russian Permian and some of the Russian geologists have considered it as of Triassic age. Under the Carboniferous system Dr. Kayser said:

We find in the states of Kansas, Nebraska, Utah, Arizona, Nevada, etc. as in central Russia, an almost exclusively marine, chalky development of the Upper Carboniferous, which gradually passes above into the marine Permian.†

Since the above was written Dr. George H. Girty has published a paper entitled "The relations of some Carboniferous faunas"‡ in which he provisionally correlates the upper Paleozoic formations of Trans-Pecos, Texas with those of Russia and Kansas. In order to understand the nomenclature applied to the geological divisions of this region it is necessary to state that Dr. Girty in 1902 proposed the name Guadalupian for apparently all the Paleozoic deposits succeeding the Pennsylvanian of that region which he stated:

"Shall be employed in a force similar to Mississippian and Pennsylvanian."*

The title of his paper "The Upper Permian in western Texas" indicated the age of the series. This region was studied later by Mr. George B. Richardson who has named the formations and referred the Hueco to the Pennsylvanian series, the Delaware Mountain formation and Capitan limestone to the Permian series to which also the Castile gypsum and Rustler formations are doubtfully referred.*

It is to be remembered in passing that the term "Delaware Mountain formation" is so similar to the Delaware limestone of Orton, a name applied in 1878 to a Devonian formation of Ohio,† that it is not a sufficiently distinctive designation for the Texas formation. In fact it has already been referred to as the Delaware formation which will certainly lead to confusion.

Dr. Girty discusses to some extent Dr. Tschernyschew's

* Lehrbuch d. geol. Formationskunde, 2d ed., 1902, p. 264.
† *Ibid.*, pp. 205, 206.
‡ Proc. Washington Acad. Sciences, vol. vii, June 20, 1905, pp. 1-26.
* Am. Jour. Sci., 4th ser., vol. xiv, p. 368.
* Univ. Texas Min. Surv., Bull. 9, November, 1904, pp. 32-45.
† Rept. Geol. Surv. Ohio, vol. iii, p. 606.

correlation of American upper Paleozoic deposits with those of Russia and he states that:

"I seem to see in the Texas faunas resemblances to the *Spirifer Marconi*, *Omphalotrochus Whitneyi*, *Productus cora*, and *Schwagerina* zones as their fossils are represented by Tschernyschew. All three of the lower faunas are probably represented by the Hueco formation, while the fauna of the Capitan limestone is in some respects strikingly similar to that of the *Schwagerina* zone."*

Again Girty states that

"It seems probable indeed that all four of Tschernyschew's horizons are represented in the Hueco formation, where the different faunas are not as clearly distinguishable into separate entities as in Russia.†

Girty concludes that

"On the whole, therefore, it seems to me rather more probable that much if not all of the Capitan and Delaware formations is younger than the *Schwagerina* zone."‡

In Tschernyschew's classification the Schwagerina zone is succeeded by the Artinsk stage before the Permian is reached; but it must be remembered that the Artinsk stage is referred to the Permian by a number of other distinguished European geologists.

Finally Dr. Girty makes the following comparison between the Texas and Kansas faunas:

"So far as the significance of the somewhat hastily reviewed evidence has been grasped, it seems to assign the Kansas faunas to about the horizon of the Hueco formation, placing the entire Guadalupian series, or at all events the Capitan, as a younger evolution, whether the two faunas were developed in distinct provinces or the same."*

A comparison of the faunas listed by Dr. Girty from the Hueco formation* with those also listed by him from Kansas† indicates that the faunas of none of the Kansas formations above the top of the Chase stage are related to that of the Hueco. In fact it is a question how much, if any, of the Chase stage should be regarded as homotaxial with the Hueco formation, since part of the species listed from it are generally found in the middle and lower, rather than the upper, Pennsylvanian. With the above suggestion in mind it will be seen that Dr. Girty's correlation between

* Loc. cit., p. 20.
† *Ibid.*, p. 22.
‡ *Ibid.*, p. 23.
* *Ibid.*, p. 26.
* Univ. Texas Min. Surv., Bull. 9, pp. 33-38.
† U. S. Geol. Surv., Bull. 211, pp. 77-83.

the Texan and Kansan formations probably does not differ markedly from that of other geologists and that it leaves the upper Paleozoic deposits of Kansas in the Permian.

The upper Paleozoic fauna of Kansas shows a closer relationship with the Permian of Russia than does that of the Capitan limestone as listed by Dr. Girty, which he provisionally correlates with the Permian of the Salt Range of India, the Carnic Alps and especially of Palermo, Sicily.* Consequently his statement that

"If the Capitan fauna is Permian, then certainly that of Kansas is not,"†

does not follow at all.

My original paper on "The Classification of the upper Paleozoic rocks of central Kansas" was published in 1895.‡ Additional field work and study of the Cottonwood Falls quadrangle rendered it advisable, in compliance with the custom of the United States geological survey to designate each lithologic terrane capable of representation on the topographic map as a formation, to subdivide three of the units which were described as formations in that article. The limits of part of the new formations were clearly indicated in the original paper but, in general, they were not given geographical names. Dr. J. W. Beede was associated with the writer in this later work and during the latter part of December, 1901, Dr. Beede spent some days with him in Columbus. At that time we fully discussed the classification for the formations of the Cottonwood Falls folio, selected the names for the new formations and prepared their preliminary description. The complete list of formation names for the Cottonwood Falls folio was submitted to the U. S. geological survey on March 7, 1902 and included the following six which were listed as "Prosser and Beede, new"; Elmdale formation, Neva limestone, Eskridge shales, Garrison formation, Matfield shales and Doyle shales. The above named terms were considered by the Committee on Geologic Names, March 29, 1902 and according to its chairman, Mr. Bailey Willis they "were recommended for approval without exception." The list was returned to me

* Wash. Acad. Sci., vol. vii, p. 22.
† *Ibid.*, p. 25.
‡ Jour. Geol., vol. iii, p. 682, and p. 764.

stamped as follows: "Approved [signed] C. D. W., Director." The names of the above formations, properly credited, together with descriptions and classification, were first published in the Journal of Geology in December, 1902.*

The statements on pages 54, 55, 56, 57 and 59 of Bulletin No. 211 of the United States geological survey, published the last of October, 1903, in which the authorship of the above mentioned formations is apparently claimed by Mr. George I. Adams, are, to say the least, very erroneous.

In the summer of 1896 the writer spent a few days in southern Kansas in attempting to correlate some of the upper Carboniferous and lower Permian rocks with the more prominent formations of eastern central Kansas. At that time the marked lithologic change in certain formations when followed southward from the Cottonwood Falls quadrangle was not clearly known and as the time permitted only a very hurried reconnaissance the results were not satisfactory. This was especially true regarding the attempted recognition of the Cottonwood limestone, to which the greatest amount of time was devoted. The later researches of Drs. Beede and Sellards, described in the August number of the American Geologist, show, that when followed southward from the Cottonwood Falls quadrangle, the lithology of the Cottonwood limestone and overlying Florena shales changes rapidly so that it is very difficult to determine the limestone's horizon in sections. After the writer's reconnaissance he published a preliminary paper on "The Permian and upper Carboniferous of southern Kansas"* in which a "Section along the Missouri Pacific railroad from Reece to the crest of the Flint Hills† and another "from Grenola to Grand Summit"‡ and at Cambridge§ were described. To the section from Reece to the Flint Hills the writer was able to give but a half day for investigation and from below Grand Summit to Cambridge, only a day. According to Drs. Beede and Sellards, the soil and loose material had been removed from the railroad right

* *Op. cit.*, vol. x, pp. 703-719, and date of publication was *prior* to December 8.

* Kan. Univ. Quart., vol. vi, 1897, pp. 149-175.

† *Ibid.*, pp. 152, 153.

‡ *Ibid.*, pp. 160-162.

§ *Ibid.*, pp. 166, 167.

of way in the vicinity of the cuts on the eastern slope of the Flint hills to the west of Reece just previous to their work so that there were "ideal exposures from which to make exact sections." Their detailed studies aided by these excellent exposures showed that the upper part of my section needed correction as they have indicated. At the time of my work the covered slopes misled me regarding the thickness of the strata between the upper cuts so that the total thickness was underestimated and the upper portion of the section correlated incorrectly. No's. 13, 14, and 15 of my section were correlated with the Strong flint,* now known as the Wreford limestone; but Beede and Sellards show that only No. 13 and the lower 15 feet, 8 inches (their measurement) of No. 14 belong in the Wreford limestone, which then has a total thickness in this section of over 27⅔ feet. The remainder of No. 14 represents the Matfield shales with a thickness of from 58½ feet to 62 feet, while No. 15 is the Florence flint with a thickness of from 21½ to perhaps 25 feet. The correction above made also applied to the "section of Wreford limestone near Summit Station" given in the Cottonwood Falls Folio,† where No's. 1, 2 and 3 correspond to No's 13, 14 and 15 of my original section, which has just been corrected. Making similar changes in the Cottonwood Falls Folio, No. 1, with the lower 15⅔ feet of No. 2 becomes the Wreford limestone; the remainder of No. 2 represents the Matfield shales and No. 3 the Florence flint. The statement, farther down the same column of the Cottonwood Falls Folio, that the maximum thickness of the Wreford limestone is shown at this locality should also be corrected because, apparently, only about 28 feet is shown.

As already stated, the writer had but a day for the examination of the section from Grand Summit to Cambridge and did not have another day for the continuation of the section from Cambridge to Burden. For the general stratigraphy of the region he depended on the "Geologic section from Galena to Winfield by Geo. I. Adams,"† on which the lower limestone on the eastern side of the Wal-

* Kan. Univ. Quart., vol. vi, p. 152.
† Geol. Atlas U. S., No. 109, 1904, p. 3, col. 3.
† Univ. Geol. Surv. Kansas, vol. i, 1896, pl. i.

nut river at Winfield, which is the Fort Riley limestone, when followed eastward is apparently represented as outcropping in the lower part of the slope to the west of Cambridge. The detailed investigations of Dr. Beede from Grand Summit to Burden show that the above section is incorrect and that the Wreford limestone occurs at a higher position than the supposed outcrop of the Fort Riley limestone. With this change in the general interpretation of the section it becomes evident, when the strata are followed eastward to the railroad cut east of Grand Summit, that my correlation of the upper limestones there exposed with the Strong, now called Wreford limestone, is erroneous.* Dr. Beede states that the Wreford limestone caps the top of the hills north of Grand Summit and that its base is stratigraphically at least 90 feet above the heavy limestone by the last railroad cut at Grand Summit. This shows that the very fossiliferous shales and shaly limestones, No. 28, of my section, together with the massive limestone below No. 27, do not belong in the Wreford limestone but below the middle of the next older formation, the Garrison. The statement that the fossiliferous shales of No. 28 of the Grand Summit section are equivalent to No. 14 of the section west of Reece is incorrect* as well as that in the Cottonwood Falls Folio, that the lower 25 feet of the Wreford limestone occurs east of Grand Summit station,† which should be omitted.

It is clearly shown by Beede and Sellards in the above mentioned paper that the Wreford limestone is a conspicuous formation which may be readily followed from southern Nebraska across northern and central Kansas, at least into the southern part of the latter state. This is fortunate in case the Wreford limestone be considered the base of the Permian because it will afford a marked lithologic break for the line of division between the Permian and the Carboniferous.

* Kan. Univ. Quart. vol. vi. 1897, pp. 160, 161, 163, No's. 27 and 28 of the "section from Grenola to Grand Summit."
* p. 163.
† Geol. Atlas, U. S., No. 109, p. 3, col. 3.

THE ATLANTIC HIGHLANDS SECTION OF THE NEW JERSEY CRETACIC.*

By J. K. PRATHER, Waco, Texas.

PLATES VIII, IX and X.

The sections discussed in this paper are located near Atlantic Highlands, Monmouth county, New Jersey, along the line of the Central Railroad of New Jersey from the station at Bay View avenue almost to the next stop at Waterwitch station.

The following beds are found in this section:†

	Cretacic (?)		Columbian formation.	
	Pleistocene (?)		Long Branch sand.....	4 ft.
Upper Cretacic	Monmouth....		Red Bank	100 ft.
			Navesink	40 ft.
			Mt. Laurel sand.......	50 ft.
	Upper Matawan	Hazlet sand..	Bay View Avenue sand	35 ft.
			(Upper Hazlet or Wenonah ?)	
			Marshalltown clays....*	30 ft.
			Columbus sand	10 ft.

Besides the field relations of these beds their lithological character was subjected to a careful examination. Samples of the beds were taken at intervals as indicated by the letters on the section.

Twenty c. c. of a sample was put in a wash bottle with an equal amount of soda and agitated and allowed to stand for 5 minutes, 1 hour, and 24 hours respectively, and decanted. The 1 hour and 24 hour samples contained little else than fine clay—the character of the other samples is given in a table.

The Long Branch Sand.

A yellow quartz sand not unlike the Redbank but generally has more fine clay material. It is about 4 feet thick and is quite persistent in its occurrence. There is an unconformity between this bed and the Redbank. Above the Long Branch is the Columbian gravel with an uncomformity between it and the Long Branch sand.

The Long Branch was considered Miocene by Clark, but Weller has found *Terebratula harlani* and *Gryphæa vesicularis* besides Bryozoa and considers it Cretacic.*

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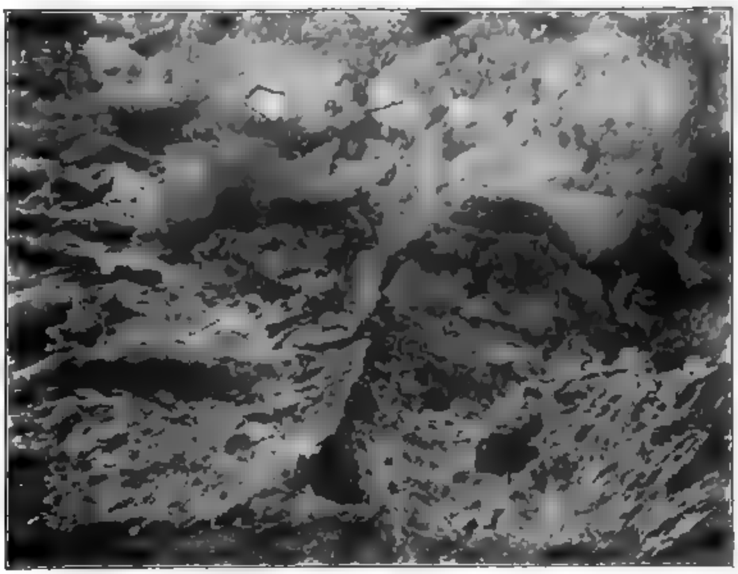
* From "The Cretacic Clays at Atlantic Highlands, New Jersey," submitted as an A. M. thesis at Columbia University, April, 1905.

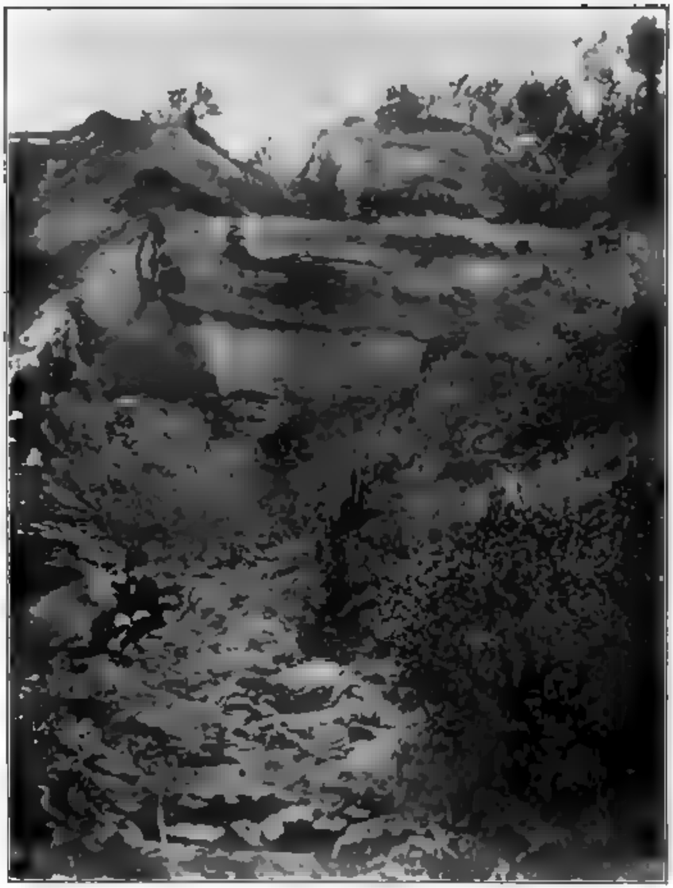
† For a complete classification of the New Jersey Cretacic see paper by Stuart Weller; "The Classification of the Upper Cretaceous Formations and Faunas of New Jersey". Journal of Geology, vol. xii. No. 1.

* See Weller's paper previously referred to (Journal of Geology, vol. xii, No. 1, p. 82.)

Atlantic Highlands as Seen from Raritan Bay



An Indurated Bed in the Redbank Sand



Section 800 Feet From Bay View Avenue.

The following table gives characters of beds below the Long Branch.

Bed*	Sample	Residue		5 minutes		1 hour		24 hours		Contains.
		cc	%	cc	%	cc	%	cc	%	
R	F^1	50.10	78.02	9.70	15.10	1.83	2.84	2.60	4.04	Almost entirely quartz grains (uniform size) rounded and triangular, mica flakes, magnetite, orthoclase, microcline, and hornblende.
N	G^2	10.00	52.58	6.9	33.01	1.0	4.78	2.00	9.56	Pure glauconite, pyrite, shell fragments, and Foraminifera.
N	G^3	14.0	63.00	6.4	28.82	1.6	7.20	0.2	0.90	Mica, 50% rounded grains of quartz, 50% glauconite.
N	A^1	6.0	33.33	5.0	27.77	3.0	16.66	4.0	22.22	Largely glauconite, also mica and rounded quartz.
N	B^1	14.0	71.06	3.0	15.27	1.5	7.61	1.2	6.09	Same as preceding.
N	C^b	11.1	66.72	3.5	20.83	2.0	11.90	0.2	0.11	No mica, 8% quartz and rest glauconite.
N	E^4	12.1	59.02	6.0	29.24	1.8	8.79	0.6	0.29	Largely glauconite with a few quartz grains.
N	G^a	11.1	52.85	9.6	45.71	0.4	0.19	0.86	0.40	No glauconite, largely quartz rounded and triangular, clay and mica.
M	C^5	9.0	46.34	6.4	32.98	2.8	14.43	1.2	6.19	Largely quartz with mica flakes.
M	coarse	3.0	15.34	24.0	72.73	1.2	6.21	1.1	5.69	Quartz rounded and angular and of varying size.
M	fine	0.05	0.28	14.00	78.55	3.5	19.66	0.3	1.50	Largely quartz, a little mica, glauconite, pyrite, gypsum, hornblende, serpentine, and fragments of older rocks.
M	D^1	3.0	15.87	14.00	74.07	1.5	7.93	0.4	2.11	Fine angular quartz, some mica and glauconite.

* N = Navesink; R = Redbank; M = Matawan.

The Monmouth Formation.

This includes the Redbank, the Navesink, and the Mt. Laurel sand, and was so named by Clark from its typical exposure in Monmouth county.

The Redbank Formation.

The Redbank formation which is about 100 feet thick at Atlantic Highlands is overlaid by the Long Branch beds or in its absence by the Columbian gravels, and rests on the Navesink beds below. It is generally of a bright red color probably due, as Clark states, to the oxidization of the glauconite grains contained in it. The color is not always a deep red and often varies from almost colorless to a vermilion. The colors, yellow, slate, salmon, pink and red are well represented in the samples I have taken. It is a sand and shows by its thickness, distribution and character of its material that it marks an important change in the history of the Cretacic beds of the Atlantic coastal plain.

At the top of the Redbank is an indurated bed called by Weller the "Tinton bed." It is probably represented at Atlantic Highlands by the indurated bed which occurs just beyond Hilton station, and between this point and Waterwitch (see plate). This bed is about 18 feet thick and higher up contains pockets of greensand which still retain the green color, although the surrounding material is red.

Mica flakes are very abundant in the Redbank, and are very characteristic. When the material is colored a deep red there seems to be an absence of glauconite grains, but grains of magnetite are found which might have resulted from an alteration of the glauconite. Some pieces of limonite about the size of one's hand were collected from the Redbank, which must be considered as due to the concentration of the iron derived from the glauconite. Samples examined under the microscope show the Redbank sand to be composed largely of quartz grains of uniform size often cementetd by fine clay colored by iron. Mica, magnetite, orthoclase, microcline, and mornblende are common.

Concretions of limestone are common, both rounded and stalactitic in form.

The Redbank forms a large part of the hills around Atlantic Highlands. Its thickness and color make it an im-

portant and characteristic member of the New Jersey Cretacic.

Both Cook and Clark have included a part of the upper Navesink with the Redbank, but the lithological character of the material of the two formations is so different (one being a quartz sand and the other a clay or glauconite bed) that the line of separation can be traced without much difficulty. The material of these beds was undoubtedly derived from the older rocks to the southeast, as already suggested by Cook.* Clark gives the strike North 50° East with a dip of 25 feet to the mile.

The Navesink Marl.

This was named by Clark from its typical development in the vicinity of the "Highlands of Navesink," Monmouth county, New Jersey. He gives its thickness as 30 to 50 feet with the same dip and strike as the Redbank. This is one of the most important divisions of the New Jersey beds, and besides yielding 300-400 species of invertebrates, it contains more glauconite on the whole than is found in any other of the divisions. It is well exposed at Atlantic Highlands where it varies from 10 to 50 feet in thickness. It is generally of a dark green to light grey color while some layers are so dark as to be called black. These dark layers may be due to a certain amount of vegetable matter mixed with the glauconite. The light grey color comes from weathering and may partly be due to the decomposition of the pyrite contained in the bed. The dark layer which is generally about 10 feet thick may even assume a blue color.

There are three distinct fossil beds in the Navesink which I have called bed 1, bed 2, and bed 3, beginning at the top. The fossils in bed 1 (which is characterized by *Exogyra costata* and *Ostrea larva* are replaced by limonite which, being characteristic, separates these fossils from those of the other two beds. Bed 2 is the *Gryphæa vesicuaris* bed which also contains *Bellemnitella americana*, *Ostrea larva*, *Exogyra costata*, and *Terrabratella plicata*. The fossils in this bed have the parts of the original shells while those of the other beds are chiefly internal molds. There is much clay mixed with the glauconite and the formation on

* Geology of New Jersey, 1868.

the whole is what might be called a clay green sand. Flakes of mica and grains of quartz and feldspar, chiefly orthoclase, but with some microcline, are numerous throughout the bed. Hornblende and pyroxene are also found but they are not so common. The beds weather readily under the influence of the atmospheric agencies and much trouble is experienced by those whose houses are built near the edge of the bluffs on account of the tendency of the material to slide down. In some places where there is a good deal of water percolating over the embankment the material becomes hard and smooth and changes to a black color. The glauconite grains change the color to a brownish yellow, to a black, to a dark blue, to a dark green, or to a pea green, according to the state of decomposition. The beds contain pieces of lignite, and I collected one piece about 5 inches in diameter and about 8 inches long. It was broken out of a steep bank and part of it was left in the bank. Near the top of the Navesink marl is a clay iron stone layer 2 to 4 feet thick, containing numerous glauconite grains. These are held together by the cementing substances of the clay iron stone which is a mixture of limonite and clay. The iron may have been originally a chemical precipitate or it may have come in part from the breaking up of other glauconite grains which had been formed at an earlier period. Bed 1 which is 4 feet to 20 feet thick is a clay containing numerous quartz and feldspar grains and mica flakes, and is characterized by the filling of limonite in the cracks, which are very numerous throughout. The color of the material of this bed is a light grey. Bed 2 is a mass of glauconite grains embedded in a clay of light grey color. This bed is in places made up of a mass of shells. It contains practically no quartz or feldspar grains or mica flakes.

For separation of samples from Navesink see table.

In a sample (G^2 taken from Bed 2 (*Gryphæa vesicularis* bed) there was practically nothing besides glauconite grains and a few shell fragments. Some grains of pyrite were found and some shells of Foraminifera (Nautilus type; Trochoid type; Nucularia type; Nodosaria type) were noted.

In a sample (G^3 taken from bed 3) there is ½ quartz and ½ glauconite. There are well formed crystals of gypsum

in this bed which are of secondary origin. Many samples of the Navesink are made up almost entirely of glauconite grains with only enough fine material to hold them together. The glauconite grains may be only slightly altered but in some instances (sample A[1]) they are changed to a dark brown color, when it takes a good magnifying glass to distinguish them. In this sample mica is found and there are some quartz grains which are larger and more rounded than one would ordinarily expect from the sample. The samples grade from almost pure glauconite to no glauconite grains at all, and mica is generally absent but may be in certain cases abundant. The amount of quartz is variable, ranging from 50% to zero. The feldspar though present only shows in the thin sections as it is too opaque to be told without grinding down the sample.

The Navesink is marked by a fossil bed near its base which bed is very persistent along the whole section, and care should be taken not to confuse these fossils and assign them to the beds underneath as has sometimes been incorrectly done by some of our best workers.

It is to be noted on the whole that in the samples taken much glauconite is found. Besides this many fragments of the older rocks, or land derived material, occur, indicating a near shore deposit. There is much argillaceous material to be found in the samples. The upper part contains more land derived material and mica flakes, and arenaceous material is more common in this part. The principal fossil bed which is designated as bed 3, is the lowest of the three beds which contains the fossils.* It is of varying thickness, generally about 3 feet thick, but often as thick as 10 feet. This lower fossil bed is in some places found where the two beds, bed 1 and bed 2, are missing. It generally contains a considerable amount of indurated material. The color of the Navesink beds is generally darker than those of the Matawan, and they contain more glauconite and less fine material and do not contain the layers and pockets of sand or of clay, which characterize the Matawan formation.

There is an uncomformity between the Navesink and the Redbank showing that erosion has taken place. This

* For a list of species see below.

is indicated by its thinning to the eastward and the absence of the two upper fossil beds which are present in the western part.

The character of the beds renders them easily eroded and the exposures are constantly changing owing to the undermining which is continually going on.

Locally the Redbank alternates with the Navesink due to slipping. At one place the layers can be traced across and a drop of fifty feet is noted.

Fossils from the Navesink.

Owing to atmospheric agencies which cause the higher parts to disintegrate and slide down over the more basal portions, it becomes necessary that the fossils of each bed be carefully collected and studied so as to separate them, for they have been generally intermixed. I have found fossils from a bed at the top of a bluff scattered all the way from the top to the bottom. Both Clark and Whitfield state that the fossils have been collected and labelled in such a way that it is impossible to tell in many instances to what beds they properly belong.

The fossils in the list which follows are from the Navesink, and one of the objects of this paper is the study of this particular bed, ascribing to it the fossils which belong to it, in order to help differentiate the fossils and assign them to the beds to which they properly belong.

In this list the fossils are indicated as follows: very common; common; rare, and very rare: U= given by Whitfield from upper marl; M= given by Whitfield from middle marl.

Gastropods	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Natica abyssina (Morton)........		Bed 3		×		
Voluntoderma abbotti (Gabb)....	M	"	×			
Turbinopsis elevata (?) (Whitf.).		"			×	
Odontofusus medius (Whitf.)...		"				×
Rostellaria compacta (Whitf.)..		"			×	
Bulla conica (Whitf.)..........	U	"			×	
Xenophora lapiferens (Whitf.) .	U	"			×	
Lunatia halli (Gabb)..		" 1 and 3		×		
Calyptraphores velatus (Conrad).	U	" 3			×	

Gyrodes infracarinata (Gabb)....		"	×			
Odontofusus rostellaroides (Whitf)		"			×	
Trachytriton atlanticum (Whitf.).		"			×	
Modulus lapidosus (?) (Whitf.)..		"			×	
Turritella vertebroides (Morton).		"		×		
Turbinella (?) parva (Gabb)....		"			×	
Trematofusus venustus (Whitf.)..	U	"			×	
Pyropsis perlata (Conrad)......		"	×			
Pyropsis reileyi (Whitf.)........		"	×			
Tudicula plonimarginata (Whitf.)		"	×			
Pyropsis trochiformis Tuomey)..		"	×			
Rostellaria spirata (Whitf.)......		"				×
Pyropsis richardsoni (Tuomey)..		"		×		
Gyrodes altispira (Gabb)........		"	×			
Rostellites angulatus (Whitf.)...		"	×			
Volutomorpha mucronata (Gabb)		"	×			
Volutomorpha conradi (Gabb)....		"	×			
Rostellaria nobilis (Whitf.)......	U	"	×			
Volutoderma ovata (Whitf.)......		"				×
Turritella encrinoides (?) (Morton)		"		×		
Gyrodes obtusivolva (Gabb).....		"		×		
Rostellites nasutus (Gabb).......		"			×	
Volutomorpha ponderosa (Whitf.)		"			×	
Cithara croswickensis (Whitf.)..		"			×	
Pyropsis retifer (?) (Gabb)......		"				×
Pyrifusus turritus (Whitf.)......		"				×
Odontufusus typicus (Whitf.)....		"			×	
Rostellites biconicus (Whitf.)....	U	"				×
Pyropsis corrina (Whitf.).......		"				×
Gyrodes petrosa (Morton)........		"	×			
Trachytriton multivaricosum (?) (Whitf.)		"				×
Rostellaria fusiformis (Whitf.)..		"	×			
Rostellaria curta (Whitf.).......		"				×
Turritella lippincotti (Whitf.)...		"				×
Turbinella (?) verticalis (Whitf.)		"				×
Pyrifusus multicaenais (Whitf.)..		"				×
Anchura compressa (Whitf.).....		"	×			

Palecyopods.	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Ostrea larva (Lamark)........	U & M	Bed 1, 2 & 3		×		
Idonearca antrosa (Morton). .		" 3		×		
Idonearca vulgaris (Morton)..		"		×		
Ostrea glandiformis (Whitf.)...	U	"			×	
Claragella armata (Morton)...		"	×			
Legumen appressum (Conrad)		"	×			
Diceras dactyloids (Whitf.)...		"			×	
Cardium prelongatum (Whitf.)		"		×		
Trigonia mortoni (Whitf.). ..		"		×		
Exogyra costata (Say)........		" 1, 2 & 3		×		
Veniella conradi (Morton)....		" 1 & 3		×		
Dianchora echinata (Morton)..		" 2		×		
Neithea quinqucostata (Lamark)		" 3			×	
Gryphaea vesicularis (Lamark)		" 2 & 3		×		

Veniella subovalis (Conrad)..		" 3			×	
Lucina smockana (Whitf.)....		"				×
Lithodomus ripleyana (Gabb).		"		×		
Arca quindecemradiata (Gabb)	U	"				×
Inoceramus sagensis (Owen)..		"		×		
Nemodon anfaulensis (Gabb).		"				×
Nemodon angulatum (Gabb)..		"				×
Cibota obesa (Whitf.)........		"		×		
Nucula slackiana (Gabb)......		" 1				×
Perrisonata protexta (Conrad)		"		×		
Veniella trigona (Gabb).......		" 3		×		
Liopistha protexta (Conrad)..		" 1 & 3		×		
Arca transversa (Gabb)......		"			×	
Bibotá uniopsis (Conrad).....		"				
Inoceramus saganensis var quad-				×		
raus (Whitf.)		"				
Inoceramus pro-obliqua (?)			×			
(Whitf.)		2 & 3	×			
Pecten venustus (Morton)....						
Neithea quinquecostata (La-		3	×			
mark)		" 2			×	
Ostrea tecicosta (Gabb).......		" 1			×	
Anonia tellinoides (Morton)...		"				
Inoceramus sagensis var vanux-						
emi		" 3			×	
Crassatella rembea (Whitf.)...	U & M	" 3		×		
Ostrea larva var nasuta (Mor-						
ton)	U & M	" 2		×		
Corbicula species		" 3		×		
Panopea dicisa (Conrad)......		"			×	
Leiopistha inflata (Whitf.)....		"	×			
Pachycardium burlingtonense						
(Whitf.)		"				×
Gnathodon tennidens (Whitf.)		"		×		
Cyprimeria densata (?) (Con-						
rad)		"				×
Cardium multiradiatum (Gabb)		" 1 & 3		×		
Cardium dumosum (Conrad)..		" 3		×		
Cyprimeria spissa (Conrad)..		"			×	
Crassatella littoralis (Conrad).	U	"			×	
Dosinia gabbi (Whitf.)........		"			×	
Crassitella curta (Conrad) (?).	U	"		×		
Leiopistha protexta (Conrad)..		"		×		
Modiola inflata (Whitf.).......	M	"		×		
Exogyra lateralis		" 2			×	
Exogyra costata		"1, 2 & 3		×		
Crassatella vadosa (Morton)...		" 3			×	
Crassatella sp.		" 1				×
Corbicula sp.		" 3				×
Inoceramus sp.		"				×
Neithea quinquecostata (La-		"				
mark)		"				×
Veleda tellinoides (?) (Whitf.)		"				×
Donax fordi (Lea)		"				×
Leptosolen biplicata (Conrad)		"				×
Callista delawarensis (Gabb)..		"				×
Cyprimeria excavata (Morton)		"				×
Astarte veta (?) (Conrad)....		" 1			×	
Panopea elliptica (?) (Whitf.).	U	" 3				×
Modiola sp.		"			×	
Cardita britteni (Whitf.)......	U	"			×	

Nuculana species		" 1			×	
Dosinia gabbi (Whitf.)		" 2		×		
Crassatella alta (Conrad)	U	" 3	×			
Gryphaea (several species)		"		×		

Miscellaneous.	Other Beds	Navesink	Common	Very Common	Rare	Very Rare
Crabs claws (described by H. A. Pillsbry ?)		Bed 3		×		
Fish vertebræ (large and small)		"	×			
Fish teeth (various sizes)		"	×			
Sharks teeth (Cestraciont and squalodonts)		"			×	
Coprolites (different kinds)		"	×			
Belemnitella americana (Morton)		" 2		×		
Sponges		" 3			×	
Baculites compressus (Say) Morton		" 3		×		
Baculites ovatus (Morton)		"		×		
Baculites asper (Say)		"	×			
Nautilus dekayi (Morton)		"			×	
Turrilites pauper (Whitf.)		"				×
Architectonica annosa (Conrad)	U	"				
Heterococeras conradi (Morton) Gabb		" 2		×	×	
Terebratella plicata (Say)		" 2 & 3				×
Bryozoa		" 3	×			
Serpula cretacea (Conrad) (?)		"		×		
Plant remains (?)		"			×	
Gastrochæna americana (Gabb)	M	"		×		
Dentalium subarcuatum (Conrad)		"		×		
Dentalium falcatum (Conrad)		"		×		
Siliquaria pauperata (Whitf.)		" 1				×
Margaritella abbotti (Gabb)		" 1				×
Neptunia sp.		" 1				×

Mt. Laurel Sand.

Clark gives the Mt. Laurel sand as 5 feet thick at Atlantic Highlands, and includes it with the Navesing and with the Redbank in the Monmouth formation.

At Atlantic Highlands it appears as an oxidized zone beneath the Navesink and is about 5 feet thick. It was traced from Bay View avenue station at Atlantic Highlands in the direction of Hiltons for a distance of 800 feet when it grades into the Marshalltown clay bed and disappears.

Bay View Avenue Lens (2).

This is 5 feet wide and 250 feet in length and seems to be part of the Navesink. It is a dark glauconite (see sample C^b) bed and contains about 8% of quartz grains and the

rest grains of glauconite cemented by clay. No mica flakes noted in this sample. It is a very dark color which may in part be due to the presence of a certain amount of vegetable matter. It lies below the lighter colored green sand of the Navesink (samples C^a and C) and rests above Bay View lens No. 3.

The Matawan Formation.

In the western part of the Atlantic Highlands section the Mt. Laurel sand is underlaid by a quartz sand formation 35 feet thick, which can be traced eastward for 800 feet when it merges into the Marshalltown clay.

The Matawan divisions at Atlantic Highlands are included under Clark's Hazlet sand or Upper Matawan. The divisions are "Bay View Avenue sand," (which I have named provisionally, which represents uppermost Hazlet, and may be Knapp's Wenonah sand). Below this sand, near Bay View avenue, is 30 feet of the dark laminated Marshalltown clay. This latter is 43 feet thick at the eastern end of the section where it has replaced the Bay View Avenue sand. Below this forming the base of the section throughout is the Columbus sand which grades upward into the Marshalltown clay. The Marshalltown clay here is at the top marked by an unconformity.

The Matawan beds at Atlantic Highlands are not very fossiliferous, and besides fragments of a crab's claw there were few fossils obtained from them.

From samples examined with the microscope it was shown that the material composing the beds was largely quartz grains both rounded, flattened, and angular, together with some glauconite grains and mica flakes. Also in some samples hornblende, gypsum, pyrite, serpentine, orthoclase, microcline, pyroxene, etc. were found. There is more or less clay with glauconite grains either disseminated or in pockets. The strike is northeast to southwest—dip 25 feet to the mile as given by Clark.

Following are the detailed characters of the various members of the Matawan series beginning with the highest.

Bay View Avenue Sand.

This is so named from Bay View avenue station near Atlantic Highlands where it occurs. It is from 15 feet to

25 feet in thickness and extends from Bay View avenue in the direction of Hiltons some 800 feet. It is a sand as shown when separated and examined under the miscoscope although it appears at first sight to be a compact clay. It is sometimes found as one bed, or may be made up of a number of small beds or lenses of only local extent varying in thickness from 2 feet to 8 feet (see lenses 4 and 5). The color varies from white to yellow, salmon, brown, orange, and red. It is made up almost entirely of quartz grains with grains of iron, probably magnetite, mica, and some glauconite. The quartz grains are both angular and rounded and are generally of uniform size, although larger and more rounded quartz grains are noted. It rests above the Marshalltown clay and below the Navesink and Mt. Laurel, although the upper Marshalltown clay seems to be about the same age. Sometimes it is coarse like an ordinary sand, and again it is finer grained like a clay. This is probably the upper part of the Hazlet sand of Clark. Part of it may correspond to the Wenonah sand of the New Jersey survey, although on account of local variation it does not seem to fit this so well, and is therefore given a local name.

Bay View Avenue Lenses, (1), (3), (4), *and* (5).

These four lenses are included as part of the Bay View Avenue sand and as part of the Mt. Laurel sand. No. (1) is 4 feet thick and 120 feet long; No. (3) is 4 feet, 5 inches thick and 120 feet long; No. (4) is 2 feet thick and 130 feet long; and No. (5) is 2 feet thick and 70 feet long.

No. (1) is very fine grained and of a light color. It contains quartz and mica but has so much fine clay as to render it a clay rather than a sand, and causes it to break into hard lumps.

No. (3) is much coarser and more arenaceous than No. (1) and contains more glauconite and more quartz and less fine clay. It is a brown color and readily separates into a sand. Nos. (1) and (3) are part of the Mt. Laurel sand.

No. (4) is fine grained like No. (1) but of coarser grain. It breaks up into lumps and has so much fine clay as to make it a clay rather than a sand. It contains quartz and mica but the clay predominates. It is of a light grey color and contains very little glauconite.

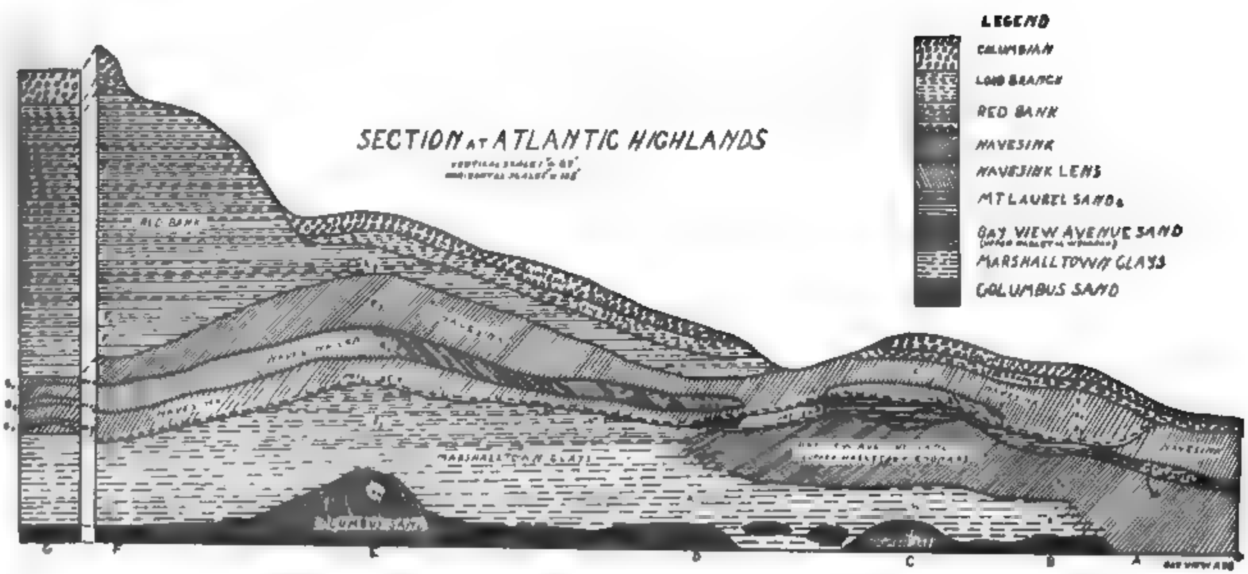
No. (5) is a brown sand but fine grained and containing much fine clay. The grains of quartz and mica are also very small. Nos. (4) and (5) are part of the Bay View Avenue sand.

Marshalltown Clay.

The bed here identified is from 15 feet to 43 feet thick and extends from 200 feet from Bay View avenue to near Hiltons station. It represents part of the Hazlet sand of Clark and would correspond to the (Clay marl 4) Marshalltown bed of Knapp. It is a dark colored clay which varies in color from black to a light grey, when it has a silvery or micaceous appearance. Examined under the microscope it is found to be composed largely of clay and quartz grains, and some mica flakes. It is finer grained, darker in color and very different from the beds, one above, and the other below it, for they are arenaceous (silic arenites) and composed largely of quartz grains, while this bed is more of a clay or clay marl. It might be suitable for making brick or certain grades of earthenware. It is finer grained than the Navesink which rests above it in part of the section, but, in the rest of the section, the bed called Bay View Avenue sand comes in between. It contains very little glauconite and is generally very fine grained and contains much fine quartz and mica and a good deal of fine clay.

Columbus Sand.

This generally occurs at the base of the sections from Bay View avenue to near Hiltons. It represents the Upper Hazlet sand of Clark. It seems to be a part of the overlying bed in certain instances and lenses (6) and (7) of this sand are included in the Marshalltown clay above. It varies in color from white to yellow and red, may even assume a slate color owing to the clay present in it. It contains interstratified layers of slate colored clay which is very smooth and fine grained. It is made up largely of quartz grains of variable size, and often highly colored. It contains numerous flakes of mica and many grains of glauconite scattered through it, some of which have been altered to iron compounds. Besides the color, the pieces of clay and the mica flakes are most characteristic. It varies in thickness from 5 feet to 25 feet although on ac-



Section Three Fourths Mile From Bay View Avenue

count of being at the base, it is not always completely exposed.

SECTIONS.

The following sections taken at intervals give the detail of the formations:

Section 250 feet from Bay View Avenue.

Samples				
	Conglomerate at top..... 2 ft.	Columbian gravel	
	Sand .... 3 ft.	Long Branch.	
B1 & B2	Light greensand ....10 ft.	Navesink.	
B3......	Dark greensand .... 6 ft.	Navesink.	
B4......	Fossil bed with glauconite grains .... 6 ft.	Navesink.	
B5......	Light clay (cream colored) with few glauconite grains (Lens 1)........ 4 ft.	Mt. Laurel sand.	Upper Matawan or (Hazlet sand)
B6 & Ba	Brown clay containing much quartz grains and mica and with glauconite grains disseminated through it ....12 ft.	Bay View Avenue sand.	Upper Matawan or (Hazlet sand)
B7......	Dark clay made up largely of clay and a good many quartz and mica grains 11 ft.	Marshalltown	Upper Matawan or (Hazlet sand)
	Light gray sand largely quartz with some mica with interstratified layers of clay .... 6 ft.	Columbus sand.	Upper Matawan or (Hazlet sand)

Section 450 feet from Bay View Avenue.

Samples.		
	Quartz pebbles (conglomerate) at top 2 feet	Columbian
	Quartz sand ....5 feet	Long Branch
C1	Light greensand chiefly glauconite.....7 ft. Grains cemented.	Navesink
Cb	Dark greensand most all glauconite....5 ft. Grains cemented together (Lens 2).	Navesink

C2	Brown clay, light brown color and with much quartz (Lens 3)	4.5 ft.	Mt. Laurel	Upper Matawan or (Hazlet sand)
C3	Brown clay, still lighter color than preceding but composed of same materials (Lens 4)	2 ft.	Bay View Avenue sand.	
C4	Brownish yellow clay made up largely of quartz grains (Lens 5)	2 ft.		
C5	Light brown clay with quartz grains and flakes of mica embedded in the clay ground mass	15 ft.		
C6	Dark grey clay with fine quartz grains	12 ft.	Marshalltown	
C7	Light grey sand largely quartz and some mica with interstratified layers of clay	8 ft.	Columbus sand.	

Section in bend of Creek 800 feet from Bay View Avenue.

Samples.	Quartz pebbles and sand	20 ft.	Columbian 3ft. Long Branch 5 ft. Redbank 12 ft.	
D2	Greensand dark colored and made up largely of glauconite grains cemented and with some grains of quartz and mica scattered through (*)	10 ft.	Navesink	
D1	Dark clay made up largely of clay and a good many quartz and mica grains.	35 ft.	Marshalltown	Upper Matawan, or (Hazlet sand)
	Dark gray sand, largely quartz with some mica and interstratified with layers of clay	6 ft.	Columbus sand	

* Both the Bay View Avenue sand and the Mt. Laurel sand grade into the Marshalltown clays here and disappear.

Section 1250 feet from Bay View Avenue.

Sample	Material	Thickness	Formation	Group
	Quartz pebbles at top	5 ft.	Columbian gravel	
	Quartz sand	5 ft.	Long Branch	
E2	Quartz sand, salmon colored made up of quartz and some mica and magnetite grains	6 ft.	Redbank	
E3	Light colored clay with quartz and mica in large flakes and some glauconite but glauconite rather rare	20 ft.	Navesink	
E4	Dark green and layers composed of glauconite grains cemented	10 ft.	Navesink	
	Light greens and layers	10 ft.	Navesink	
E5	Dark grey clay made up largely of clay with much quartz and mica	25 ft.	Marshalltown	Upper Matawan or (Hazlet sand)
E6	Light and dark grey to yellow sand with interstratified layers of clay. The material is largely grains of quartz with large mica flakes and some grains of glauconite	20 ft.	Columbus sand	Upper Matawan or (Hazlet sand)

Section 1600 feet from Bay View Avenue.

Samples.	Material	Thickness	Formation	Group
	Quartz pebbles	10 ft.	Columbian	
	Sand	5 ft.	Long Branch	
Fa & F1	Red sand changing from dark red to yellow salmon, grey, &c., largely quartz	9.5 ft.	Redbank	
F2	Light green sand	10 ft.	Navesink	
	Dark greens and nearly all glauconite grains cemented together	10 ft.	Navesink	
	Light green sand	10 ft.	Navesink	
	Dark green clay made up of quartz and mica grains in clay	25 ft.	Marshalltown	Matawan (Hazlet sand)
	Light colored quartz sand with layers of interstratified clay	5 ft.	Columbus sand	Matawan (Hazlet sand)

Section 3960 feet from Bay View Avenue.

	Quartz pebbles and sand	10 ft.	Columbian
	Sand	5 ft.	Long Branch
	Red sand largely made up of quartz grains with some hard cemented pieces	90 ft.	Redbank
G1, G2, G3	Glauconite beds with much clay and quartz grains near the top and with less quartz and more glauconite near the middle and bottom, and with numerous fossils especially in bed 3 or basal portion of bed	20 ft.	Navesink

These sections and the intervening parts are shown on the drawing made to scale from measurements and notes taken in the field (Plate x). The sections were drawn to scale on tracing cloth and taken into the field and the beds separately traced out and mapped and the intervals filled in while in the field. The letters A1, B1, &c, refer to samples of the beds, located on the section at the points where they were taken. (See also plates viii and ix).

CONTRIBUTIONS FROM THE MINERALOGICAL LABORATORY OF THE UNIVERSITY OF WISCONSIN.

By William Herbert Hobbs, Madison, Wis., Assisted by others.

PLATE XI.

In the following pages have been brought together a number of brief statements which it is thought are deserving of being placed upon record. Undertaken from time to time as material has come to the laboratory they have been allowed to wait until collectively they had a value which individually would not belong to them. The economical and mineralogical work has been carried out in part by the professor in charge of the department, or by his students, but generally in collaboration. Credit for work is given in connection with the individual contributions.

*a. Analysis of Huebnerite from Dragoon Summit, Ariz.** by S. V. Peppel. The specimens of this mineral are cleavage blades from large hair brown crystals two inches or more in length. An analysis of them yielded the following results:

SiO^2†	1.10
WO^3	75.10
MnO	22.87
FeO	.81
	99.88

The re-calculated analysis excludes the silica, which is probably included material. This analysis appears below in column I, and in column II is given the theoretical composition of pure huebnerite.

	I.	II.
WO^3	76.13	76.6
MnO	23.15	23.4
FeO	.82	
	100.00	100.00

b. Quartz Crystals from near Las Vegas, N. M. These specimens were received from Mrs. A. P. Buck, East Las Vegas, N. M. They constitute numerous double-terminated crystals of clear colorless quartz of great pellucidity resembling in habit the Herkimer quartzes from New York

* This occurrance has been described by W. P. Blake in the Mineral Industry, vol. 7, 1899, pp. 720-722.

† And oxides of columbium group, if present.

state. In common with Herkimer quartzes, also, these crystals are found with much lustrous black material which glows and becomes white on ignition and appears to be in part like the included material of the Herkimer crystals. The crystals sent are somewhat smaller than the average of those obtained from Herkimer county, but they yet resemble them quite closely. These crystals are reported by Mrs. Buck to occur in "veins" in the high country near Las Vegas, hundreds being there found in each shovelful of earth, and the best crystals being obtained in pockets along with the lustrous black material of which, however, only a small amount was included with the sample.

c. Calcite, Sphalerite, and Pyrite from Oshkosh, Wisconsin. The specimens of these minerals were collected from the dolomyte quarry one mile southwest of the city of Oshkosh and presented to the university of Wisconsin by Mr. T. J. Thorson. The calcite shows two habits; one having the form r, $(10\bar{1}1)$ unmodified, the other exhibiting the forms f, $-2R$ $(02\bar{2}1)$; v, R^3 $(21\bar{3}1)$; e, $-\frac{1}{2}R$, $(01\bar{1}2)$; m, ∞P $(10\bar{1}0)$; and r, R $(10\bar{1}1)$, the latter form small.

The sphalerite shows the ordinary combination of dodecahedron and trapezohedron (311).

d. Minerals from Eau Claire, Wisconsin. Specimens of pyrite, marcasite, sphalerite, chalcopyrite, and dolomite have been obtained from this locality. The pyrite occurs in well formed octahedral crystals up to ½ centimeter in diameter, with the cube and dodecahedron truncating the angles and edges respectively. The crystals show a greenish to bluish iridescence. Marcasite occurs together with the pyrite and in the common tabular forms which are bounded by the base, unit prism, and one or more of the brachy-domes v. and l. The dolomite occurs in a simple rhombohedron, while the chalcopyrite is found only massive.

e. Dolomite and white Zinc Oxide from Highland, Wisconsin. The dolomite occurs in lenses of small gray and curving faced rhombohedrons with dimensions of a few millimeters only. The specimen of zinc oxide was presented by Mr. Richard Kennedy, mining expert, resident at Highland. This material is quite massive and forms a coat-

ing on the limestone of the district. Its surface is botryoidal and the mineral has the appearance of having been sublimed upon the surface. In color it is almost pure white resembling magnesite; but ignited on charcoal it becomes yellow, cooling to white, and with cobalt solution gives the usual color of zinc compounds. It dissolves readily in hydrochloric acid.

f. Other Unreported Occurrences of Wisconsin Minerals. Other minerals which are not upon record, and which have been found in Wisconsin are given below.

Pyrrhotite from Mountain post office, where it is found in quite extensive deposits entirely massive in appearance.

Barite from Belmont, which occurs with brown blades as imperfect crystals up to 4 or 5 centimeters in length.

Limonite pseudomorphs after marcasite from Madison. These latter pseudomorphs show the combination of the prism m with either v or l.

Malachite; Baraboo, Sauk county.

Chalcopyrite, cuprite, and malachite; Boscobel.

Chalcopyrite, malachite; Soldier's Grove and Wayne.

Graphite; Marshfield.

g. Minerals from Helderberg Limestone of Tiffin, Ohio. The University of Wisconsin is indebted to professor M. E. Kleckner of Heidelberg university located at Tiffin, for a small collection of minerals from the quarries at that place. According to professor Kleckner the limestone of the district is part Niagara and part Helderberg, and it is in the latter that the crystallized minerals have been found. They occur as the lining of cavities some of which have a diameter, as indicated by specimens received, of one to two decimeters. Certain layers in one of the quarries have many filled cavities of cylindrical shape which have become known to the quarry-men as "plugs." These seldom extend through more than a single layer of the limestone. The minerals of this plug are the same as those filling the other cavities; namely, calcite, celestite, fluorite, and sphalerite.

The calcite is the most abundant of the minerals lining the geodes, and occurs in two different habits. The first

shows small yellow crystals ½ centimeter in length with the habit determined by the form f, —2R ($02\bar{2}1$) unmodified. The other type shows larger crystals of "dog tooth" habit which are often several centimeters in length. These crystals like the others are of a pale yellow color and their habit is determined by d, —8R ($08\bar{8}1$) with which is generally present e, —½R ($01\bar{1}2$) and t, ¼R' ($21\bar{3}4$) and sometimes v, R' ($21\bar{3}1$). The faces are more or less dull, and frequently vicinal, but allow their angles to be read with sufficient accuracy for a determination of the forms.

The celestite occurs in tabular to bladed crystals varying in size from one-half to several centimeters in their dimensions. The color is a pale blue, as in the case of the well known celestite from Put-in-Bay on lake Erie. The base is always the tabular plane and the macro-diagonal the axis of greatest development. The forms present are, in the order of relative size, c, ∞P (001); d, ½P (112); o, P$\breve{\infty}$ (011); m, ∞P (110); and z, P (111).

The crystals of fluor spar are associated with the calcite and the celestite in the cavities. They are cubes and cubo-octahedrons made up of well-rounded sub-individuals, and sometimes attain to a size of two or more centimeters along the cubic edge. Some crystals are nearly colorless and quite clear; others have areas colored yellow, but the majority of those examined have a rich brown color between that of smoky quartz and of the well-known brown siderites from Roxbury, Connecticut.

A mineral much less common in the geodes is sphalerite, which appears in distinct crystals a centimeter or more in diameter. The color is that of a light "rosin jack" and would match the color of the well known sphalerites from Joplin, Missouri. Like the latter, also, the combination found upon the Tiffin sphalerite is that of the dodecahedron with the common trapezohedron (311).

h. Calcite from Grand Rapids, Michigan. Specimens of calcite from Grand Rapids, Michigan were received from Mr. J. C. Ulman of Ashland, Wisconsin. He collected them in 1894. According to his statement the crystals are found in seams and cavities in the limestone which forms the bed

of the Grand river, coffer dams having been built and the rock quarried both for lime and for road metal. The limestone is traversed by a vertical vein of barite, containing well developed crystals. Two miles down the river the limestone dips under the well known gypsum beds of the vicinity. The rock in which the crystals here described were found, is a dark gray to white compact limestone with cavities which in many of the specimens were lined with a film of pyrite, to which the calcite crystals are attached. These crystals have been studied at the university by Mr. W. M. Kennedy. The habit of the calcite is either scalenohedral or rhombohedral, the latter variety being white and the former when found alone of a brownish-yellow color. Twins are common, the twinning plane being a face of the fundamental rhombohedron. Superimposed upon some of the larger crystals are numerous smaller and much distorted individuals so flattened as to resemble in form the tooth of a shark, the orientation being, however, the same for both larger and smaller crystals. The following forms were observed:

r, R $(10\bar{1}1)$
ϕ, $-\frac{5}{4}$ R $(05\bar{5}4)$
X, $-\frac{9}{4}$ R $(09\bar{9}4)$
𝔡, -3 R $(03\bar{3}1)$
𝔚, $-\frac{11}{3}$ R $(0.\ 11.\ \bar{1}\bar{1}.\ 3)$
ν, R^3 $(21\bar{3}1)$
M, R $\frac{11}{3}$ $(7.\ 4.\ \bar{1}\bar{1}.\ 3)$
𝔥, R $\frac{5}{3}$ $(11.\ 16.\ 5\ 6)$
and
l, $-\frac{11}{3}$ R $(11.\ 0.\ \bar{1}\bar{1}.\ 3)$ doubtful.

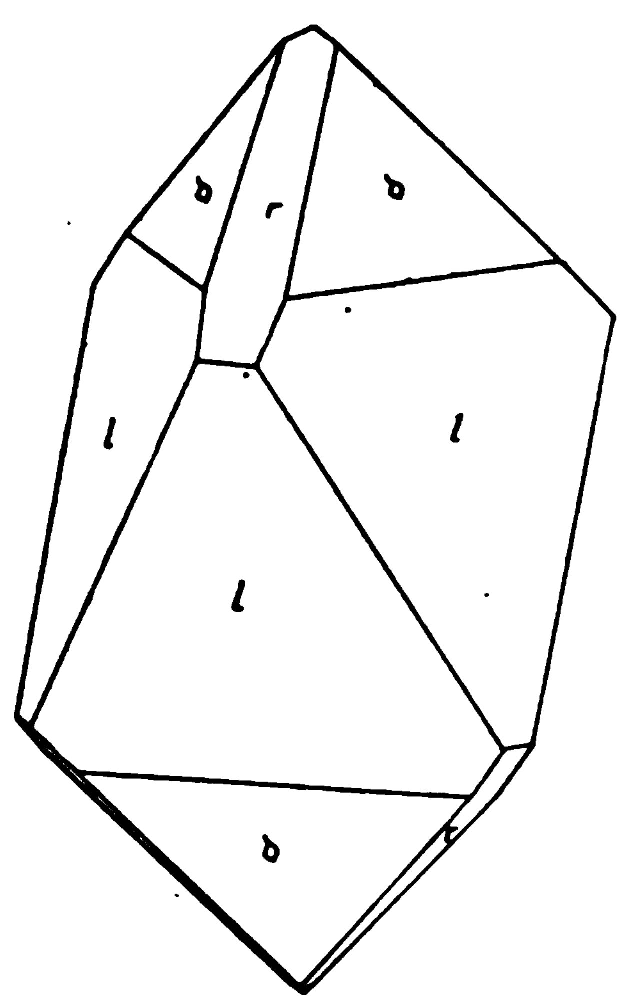


Fig. 1. Development of calcite crystals from Grand Rapids, Michigan. The angles which determined the forms were as follows:

	Obs.	Calc.	Diff.
$\phi\phi'$ (polar)	84°23′	84°32½′	—9½′
$\nu\nu'$	35°33′	35°36′	—3′
$\tau\nu$	29° 5′	29° 2′	+3′
$\mathfrak{b}\mathfrak{b}'$	32°40′	32°36′	+4′
MM′	40° 3′	40° 3′	0
r M	33° 0′	32°57′	+3′
rw	29°52′	29°54′	—2′
r δ	116° 0′	115°57′	+3′
rl	106° 0′.	105°59′	+1′

The new form R $\frac{8}{3}$ was found on a number of crystals and was accordingly determined. The form l was found on but one crystal, though here with a large development. See fig. 1.

The crystals represent a number of distinct habits among which is the barrel-shaped type of fig. 2. There is also another "nail-head" type, and a very steep rhombohedral type.

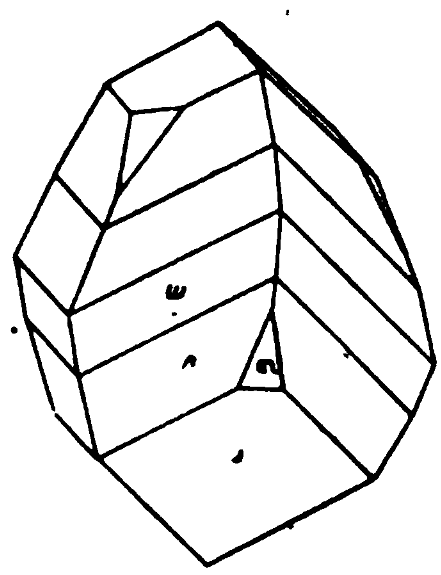


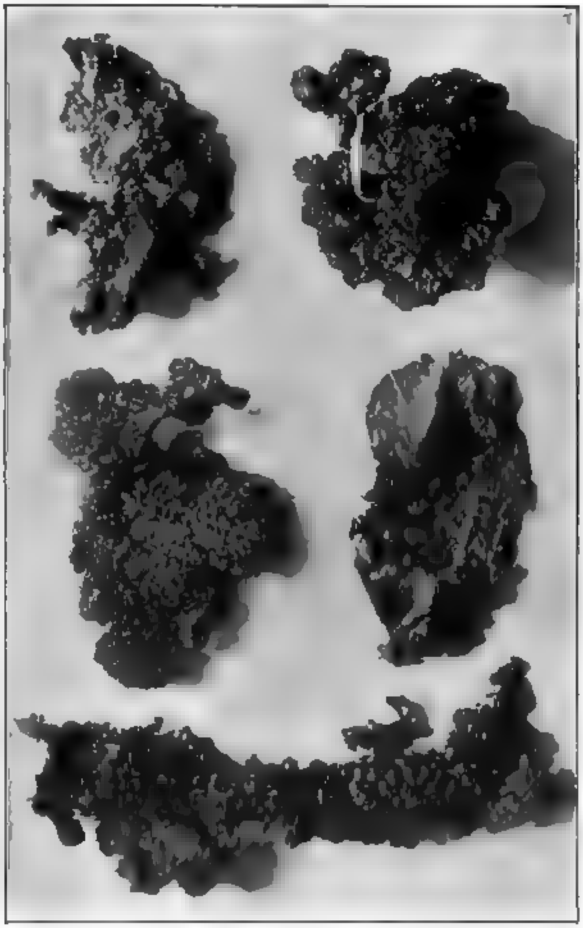
Fig. 2. Barrel-shaped type of calcite from Tiffin, Ohio.

i. Epsomite and Alunogen from the Cripple Creek District, Colorado. These specimens which were among the collections of the university of Wisconsin have been analyzed, the first mentioned by Mr. W. O. Hotchkiss, and the last mentioned by both Mr. Hotchkiss and Mr. R. M. Chapman. Their results follow:

"Epsomite" from Cripple Creek District, Colorado.

Analyzed by W. O. Hotchkiss.

MgO	19.35
SO^3	38.51
H^2O	42.03
	99.89



METALLIC COPPER, SOUDAN, MINN

"Alunogen" from Cripple Creek District, Colorado.

Analyzed by W. O. Hotchkiss and R. M. Chapman.

	Hotchkiss.	Chapman.
Al^2O^3	8.28	9.41
MgO	14.44	4.40
SO^3	34.06	43.74
H^2O	43.86	43.86
	100.64	101.41

The close similarity of the two minerals makes it difficult to obtain a perfect separation of them, and this chiefly explains the variation observed between the analysis quoted.

j. Crystallized Copper from Soudan, Minn. A very interesting and almost unique example of metallic copper in association with hematite is the occurrence at the Minnesota mine in the Vermilion iron-bearing district of Minnesota. As this occurrence does not appear to have been figured, the beauty of the films and trees seems to warrant its representation, which is given in plate xi. Although the occurrence has been described,* it does not appear to be well known, the place of publication not being well known to mineralogists. The occurrence is also casually mentioned by Clements.† Together with the hematite in association with the copper are found cuprite, malachite, and azurite. The copper minerals occur, in a narrow seam in brecciated hematite, the only place where it is found in the region or in any of the iron-bearing districts of lake Superior. This rare occurrence should be considered in connection with the discovery by Haworth of thin films of native copper in red clay shales near Enid, Oklahoma.‡ In both occurrences the copper is extremely limited and generally found in thin films upon apparent fissures. Though the Soudan occurrence was apparently not known to Haworth at the time his paper was read, he has suggested the same explanation, namely; the reduction of the copper by the oxidation of the ferrous iron compound.

* J. H. Eby, and Charles P. Berkey. Copper minerals in hematite ore. The Year Book of the Society of Engineers, university of Minnesota, 1897, pp. 108-117. Reprinted from the Proceedings of the Lake Superior Mining Institute, vol. 4, 1896, pp. 69-79.

† J. Morgan Clements. The Vermilion Iron bearing district of Minnesota. Mon. 45, U. S. G. S. 1903, pp. 112, 134. N. H. Winchell. *Metallic Copper.* Final report, Minnesota Geological Survey, vol. 5, p. 885, 1900.

It is interesting to note that beautifully crystallized copper has been produced in trees resembling the aborescent native copper of the Soudan occurrence through electrolysis.* This copper was formed at the lower corner of a full sized kathode operating under bad conditions in an insoluble anode tank, presumably with very high current density.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Structure of some Cephalopods, by R. RUEDEMANN. [Report of New York State Paleontologist 1903, Albany, 1905].

Notes on the apical end of the siphuncle in some Canadian Endoceratidae, &c. by J. F. WHITEAVES [American Geologist, Jan. 1905).

Ueber die eocambrische Cephalopodengattung Volborthella, SCHMIDT, von A. KARPINSKY, (Verhandl. russ. miner. Gesell. Bd. xli, li, pp. 31-42].

These papers with that of G. Holm 1895 on the formation of the endosiphon in the Endoceratidæ help greatly to a proper understanding of the initial stage of the shell in the early cephalopods.

Especially is this the case with the first-named essay, based upon excellent material from the oldest Ordovician limestones of lake Champlain. The essay is valuable not only for what it tells us about the Beekmantown cephalopods, but also for the synopsis which it contains of the work of other observers in this field of research—Barrande, Dewitz, Whitfield, Dawson, Hyatt, Holm, Foord, Clarke and others.

Ruedemann's work is based chiefly on the species *Camerocera, brainerdi* Whitfield, and fully describes the delicate chitinous and chitino-calcareous parts of the envelope in this species, which preceded the formation of the calcareous shell. The assumption of the calcareous habit is plainly shown in the individual history of these shells, as it is in several of the Hyolilhidæ of an earlier date. Dr. Ruedemann's work is abundantly illustrated with wood cuts in the text and a series of plates at its close. *C. brainerdi* began in a small cylindrical tube (endosiphotube, page 320) which became differentiated by the addition of an outward enclosing tube (endosiphocoleon). The first named tube fades out or loses its chiten,

‡ E. HAWORTH. Native copper near Enid, Oklahoma, Bull. Geol. Soc. Am., vol. 12, 1901, pp. 2-4.

*LAWRENCE ADDICKS. Electrolytic copper, Electro-chemical and metallurgical industries, vol. 3, 1905, p. 167, fig.

leaving the latter as the endosiphon, Chitenous or sub-chitenous supports (endosiphoblades, &c.) passing to the walls of the siphuncle held this endosiphon in its place.

Gerard Holm has found quite similar structures, though not so complete, in *Vaginoceras basaliforme*. The stage of the single worm-like tube in Cameroceras is rightly regarded by Ruedemann as an important accession to our knowledge of the initial structures in the early cephalopods.

Dr. Whiteaves' paper also has plates, two in number ,which present the characters of two new species of Endoceratites, based on the siphuncle, from Canadian localities, *Nanna primaevus* and *N. kingstonensis*. In the latter which is represented by casts of the siphuncle, the impression of the septal necks is finely shown, and the forward curve of the septal rings is well marked.

A. Karpinsky has made a fresh study of Schmidt's genus Volborthella (*V. tennuis*) from the "blue clay" of the Lower Cambrian of Reval in the Baltic provinces of Russia. He sustains the view of Schmidt that this organism is a cephalopod, since he found it characterized by a siphonal tube. It is a long space in geological time between this organism and the oldest known chambered cephalopod; perhaps the connection between Volborthella and the latter has been through some of the shells classed with the Hyolithidæ to which Volborthella bears a close resemblance. Between the "blue clay" and the Beekmantown horizon four Cambrian faunas intervene—Paradoxides, Olenus, Peltura and Dictyonema—in which no recognized orthoceratites are known. W. U,

The Copper Handbook, a Manual of the Copper Industry of the World. Vol V, for the year 1904. Compiled and published by HORACE J. STEVENS. Pages 882. Houghton, Mich., 1905.

This is the fifth yearly issue of a very comprehensive and useful handbook. It contains chapters on the history, geology, chemistry and mineralogy, metallurgy, and uses of copper; a glossary of mining terms; details of copper deposits in all parts of the world; a very extensive alphabetic list, in 683 pages, describing all the copper mines of the world, and noting all companies engaged in copper production; and statistics, in 38 pages. Concerning the very important and recent uses of this metal for telegraph and telephone wires and a multitude of other electric appliances, the compiler writes: "Copper is the foundation of the Electric Age, just as it was the fundamental metal in the Age of Bronze, some millenniums ago. * * * A full enumeration of the electrical uses of copper would require a volume." W U.

The Honorable Peter White. A Biographical Sketch of the Lake Superior Iron Country. By RALPH D. WILLIAMS Pages 205; with many portraits and other illustrations. Cleveland, Ohio, 1905.

A very interesting biography of the most prominent promoter of the mining of iron ores in the upper peninsular of Michigan is

here presented, with chapters also on the great iron ranges of Wisconsin and Minnesota. The marvelously large and growing traffic that passes through the Sault Ste. Marie canals, both on the United States and Canadian sides, and the semi-centennial celebration of the opening of the first canal there, are very fully treated. Not only biography and history, but the economic development of the lake Superior region, so far as it has depended on iron ore production, are vividly depicted; and in all the wonderful progress of that region during the past fifty years the subject of this biography was a conspicuous part. W. U.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

ALDEN, WM. C.

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CORRESPONDENCE

NOTES ON FOSSILS OBTAINED AT SANKATY HEAD, NANTUCKET IN JULY 1905.—Through the kindness of members of the Nantucket Maria Mitchell Association I was fortunate enough to make a successful collecting trip to the exposure at Sankaty Head in July of the past summer. By the united efforts of the party a section through the fossiliferous beds was laid bare and then worked systematically. The results of the collecting in this manner and also by looking over the loose material were very gratifying. The material thrown out in the previous year's excavating by Mr. J. Howard Wilson was well worked over by the rains of the previous winter and spring. In the small gullies at the base of this material small shells and crab claws were easily seen although very hard to see in the freshly exposed material. As a result of this searching a considerable number of small shells and crab claws were obtained.

One of the finds here was a single specimen of *Scala* ——— ———, making the first specimen of this species known from these deposits. The specimen was excellently preserved. A single specimen of *Scala groenlandica* Perry, was found here many years ago and was noted in the writer's previous list of the Sankaty Head fossils.

Another species of interest was *Cerithiopsis greenii* C. B. Adams, of which but very few specimens have been found at this locality. This specimen was also excellently preserved, showing the protoconch complete.

Among the smaller shells collected were several species of Odostomia. Of these the two species previously reported from Sankaty—*Odostomia impressa* Say and *O. trifida* Gould,—were the most common, the former being represented by at least three times as many specimens as the latter. Besides these two species there were found *O. fusca* C B. Adams, *O. bisuturalis* Say, and *O. seminuda* C. B. Adams. These three species have not previously been reported from Sankaty.

Among other things of interest was the finding of *Arca ponderosa* Say in situ, both valves being together and in the position of life. This species was previously known from this locality by a single valve found by the writer among the material collected by Dr. Scudder. Other pelecypods were found in the lower layer with both valves attached and the shell in the natural position. This tends to show that the shells of this layer at least are in situ and not secondarily deposited.

The crab claws collected included three species. They were identified by Miss M. J. Rathbun as *Callinectes sapidus* Rathbun, *Eupanopeus herbstii* Milne Edwards and *Neopanope texana sayi* Smith. The last was much more common than either of the other species.

In the collection at Nantucket were found two other species of very considerable interest as they were unknown from this locality at the time of publication of the former list (Am. Geol. vol. xxxiv, Sept., 1904). These include a specimen of *Sipho stimpsoni* Mörch, with an excellently preserved protoconch and a large specimen of *Chrysodomus decemcostatus* Say. This latter is a fairly complete specimen, part of the body whorl being broken away, but the spire in good shape.

JOSEPH A. CUSHMAN.

Boston Society of Natural History, September, 1905.

FIELD GEOLOGY IN OHIO STATE UNIVERSITY. Each spring term an elective course in Field Geology is offered by professor Prosser for advanced undergraduate and graduate students. The purpose of the course is to acquaint the student with the formations as they are seen in the field and to train him in the methods of investigation employed by the working geologist. The course consists of field excursions, laboratory work and study of library references.

In the field the formations are carefully studied, identified and measured preparatory to making sections and writing detailed descriptions which ultimately take the form of a thesis. In the laboratory, characteristic fossils of the various formations are identified and the literature of the region under investigation carefully studied. Last term fifteen students registered in this course, two of whom were girls, and the latter were as energetic and enthusiastic as the men. The usual equipment for the trips consisted of barometers, hand-levels and staff, tape lines, hammers, chisels, collecting bags and camera. A trip was made each Saturday during the term, with one exception, although the spring was unfavorable for field work on account of the frequent and heavy rainstorms.

Ohio state university is well situated for geological work since every formation of central Ohio is readily reached by one or more of the numerous steam or electric railways radiating from Columbus. Every formation of the state from the Richmond to the Allegheny inclusive was studied in the field save the local and relatively unimportant Hillsboro sandstone. The distance traveled aggregated about 500 miles.

The longest and most interesting trips from the standpoint of stratigraphy and paleontology were to Zanesville in Muskingum county and to Waynesville in Warren county. The latter occupied two days and included trips to the beautiful gorges at Cedarville, Clifton and Yellow Springs. Goe's Station to the south of Yellow Springs was also visited, at this time, where the mottled clays of the Saluda, the Belfast bed and Clinton limestone are excellently shown in a small ravine near the former residence of Mr. Goe. The heavy rains had thoroughly washed all of the small gullies on the hillside and the mottled clays of the Saluda were shown at their best. All of the sub-divisions of the "Niagara" of Ohio, with the exception of the Hillsboro sandstone, were studied at Yellow Springs, Clifton and Cedarville. The Osgood or Niagara shale is best exposed on the bank of Cascade glen at Yellow Springs, while farther up the stream are outcrops of the West Union, Springfield and Cedarville limestones. The gorge of the Little Miami river below Clifton is famous as one of the most picturesque localities in southwestern Ohio, its banks formed by the Springfield and Cedarville limestones. On Massie's creek, however, a little below Cedarville is a vertical cliff which is one of the most interesting places in this region since it shows the contact of the Osgood shale and West Union limestone, the entire thickness of the West Union and its contact with the superjacent Cedarville limestone. In this vicinity is a most clearly marked old channel of the creek, the bed of which is now dry and covered with grass. The Monroe formation, or Waterlime of the Ohio reports, occurs to the west of Columbus and one day was devoted to the study of several of its outcrops which involved a tramp of some twelve miles. The

Devonian limestones and shales are excellently exposed on the Scioto river and its tributaries and the various formations of the Waverly series on the streams to the east of Columbus within a distance of from ten to thirty-five miles. All of these formations were carefully studied using for a guide the recent papers of professor Prosser in which they have been fully described. The youngest Carboniferous formations studied were seen at Zanesville, sixty miles east of Columbus, where the Lower Mercer limestone occurs in the bed of the Muskingum river, and Putnam Hill and the adjacent ones show the succeeding members of the Pottsville and Allegheny formations as high as the Freeport sandstone.

GEORGE F. LAMB.

PERSONAL AND SCIENTIFIC NEWS.

MR. J. E SPURR of the U. S. Geol. Sur. has resigned to accept a position with the Guggenheim Exploration Co. Mr. Spurr has been connected with the survey for ten years and was previously with the Minnesota Geol. and Nat. Hist. Survey. He has written reports on the Mesabi range, the Mercur, Aspen, Monte Christe, Klondyke and Tonopah districts and was to have studied the Goldfield district this year. His work there will be taken up by Mr. F. L. Ransome.

WE ARE GRATIFIED TO LEARN that we have been misinformed in regard to a change in the geological survey of Michigan.—Dr. A. C. Lane is still the able director of that survey. During the present season much active work is going on. Professor Russell is making an examination of the surface geology in the Upper Peninsula, and Mr. Frank Leverett of the United States survey is on the same problem. They are working in cooperation. And at the same time professor C. A. Davis of the university is studying the development and ecology of the peat bog flora. Mr. W. C. Gordon is completing a careful cross section of the copper-bearing formation, to determine the different horizons, near the Wisconsin line. Professor W. M. Gregory is finishing his report on Arenac county. Mr. W. F. Cooper is working on the Wayne county report and watching the shaft going down to rock salt, near Detroit. The state geologist is engaged in detailed studies in the copper region.

SINCE THE RECENT REORGANIZATION of the Louisiana Survey two volumes have been published on the geology of the state, and are known generally as the "Report of 1899"

and the "Report of 1902." In preparing the "Report of 1905" it has seemed advisable owing to the diversity of subject matter, to publish the same in parts and, as usual, style such parts "Bulletins." Bulletin No. 1—Underground Waters of Louisiana; Bulletin No. 2—Magnetic Survey of Louisiana; and Bulletin No. 3—Tide Gage Work in Louisiana, have already been published and may be had gratis by addressing Dr. W. R. Dodson, director Experiment Station, Louisiana, at Baton Rouge, La. For the reports of 1899 and 1902 address "Director Sugar Experiment Sta.," Audubon Park, New Orleans, La.

STUDENTS IN THE INTERCOLLEGIATE summer field course in the geology of the Appalachian region spent the first week in studying the formations of the Coastal Plain of Maryland under the direction of Dr. Clark of Johns Hopkins university and Dr. Miller of Bryn Mawr college. Professors Bibbins of the Woman's college of Baltimore, Cleland of Williams college and Westgate of Ohio Wesleyan university were also members of the party. The boat of the city engineer of Baltimore and the private yacht of the governor of Maryland were generously placed at the disposal of the party which greatly facilitated the work. The second week under the direction of professor Davis of Harvard was spent in central Pennsylvania in studying the Appalachian structure and physiography. Professors Cleland, Westgate, Prosser of Ohio State university and Rice of Wesleyan university of Connecticut participated in this work. The third week was spent studying the formations of central New York, with headquarters at Syracuse, under the direction of professor Hopkins of Syracuse university. From Wednesday to Saturday of this week Section E of the American Association for the Advancement of Science was in session at Syracuse and the following well known geologists participated in some of the excursions: Rice, Prosser, Taylor of Indiana, David White of the U. S. Geol. Sur., Hovey of the American Museum of Natural History, Fairchild of Rochester university, Cushing of Western Reserve and Grabau of Columbia university. The party left Syracuse Saturday with professor Cushing who directetd the study of the pre-Cambrian crystalline and Ordovician formations of the Mohawk valley during the fourth week of the course.

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. OCTOBER, 1905. No. 4.

TEN YEARS PROGRESS IN THE MAMMALIAN PALÆONTOLOGY OF NORTH AMERICA.*

By PROF. HENRY FAIRFIELD OSBORN, LL. D., D Sc., New York.

Members of the Congress,

I believe that what you as specialists in the many diverse branches of zoology most desire to hear, are the salient results of our recent explorations in America, and their broader bearings on the general principles of zoology.

In 1878, the late professor O. C. Marsh published his notable address entitled: *Introduction and Succession of Vertebrate Life in North America*[2]. Fifteen years later I published a somewhat similar review entitled: *Rise of the Mammalia in North America*[3]. In the ten years which have elapsed exploration has not only been on a larger scale[4] than ever before, but also more thorough as well as guided by the constantly broadening aspects of the science.

The initial plan of the palæozoological survey undertaken by the American Museum was threefold: it was so far as possible to secure not only (1) a complete representation of certain families of mammals, as was done for monographic purposes by Marsh (i.e. Dinocerata, Brontotheriidæ)

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* Address of Prof. H. F. Osborn at the International Congress of Zoology, Berne, August, 1904. Reprinted from the Compte-Rendu of the Congress by permission of the secretary.

2 Proc. Amer Assoc. Adv Sci, Nashville, 1877, pp. 211-258.

3 Amer. Jour. Sci. 13, xlvi, 1893, pp. 379-392, 448-466.

4 Large collections have been secured by the Museums of Princeton University and the University of California, by the Carnegie Museum Pittsburgh, the Field Columbian Museum, Chicago, and some few additions have been made to the famous collection brought together by professor MARSH at Yale University.

The Department of Vertebrate Palaeontology in the American Museum of Natural History was founded with the present writer as Curator in 1891. Associated with him at various times were the following zoologists and palaeontologists: Messrs WORTMAN, MATTHEW, EARLE, GIDLEY and BROWN. Fossil mammals brought from the West, secured by exchange, and by purchase, including the entire collection of the late professor Edward D. Cope, now number 9873. The Cope Reptilian and Amphibian Collection is also in the American Museum.

(2), a complete representation of certain contemporary faunas, as was done chiefly by the late professor Edward D. Cope (e. g. the Puerco and John Day faunas), but in addition (3) to secure complete phyletic series of various families of mammals in successive geological horizons from their introduction to their extinction (compare Fig. 2). In each of these features of our plan we have been rewarded with a success far beyond our most sanguine expectations. Our large collections studied by friendly cooperation in connection with those of other institutions, and large collections studied independently in other institutions, notably Princeton and the Carnegie Museum, have naturally brought into a new light some of the important general principles of palæozoology.

I. Progress in the General Principles of Palæozoology.

Palæogeography—The first broader bearing is that of past distribution and palæogeography, in which the accuracy of our records[1] and thoroughness of our search are working a revolution. We are finding the remains of animals which have recently arrived from South America, Asia, Europe[2] and Africa[3], and it would be impossible to narrow the field of American fossil mammalogy even if we desired to do so. The broad study of intercontinental evolution and relations of the mammals is absolutely essential to a philosophical understanding. Those who have followed the rapid recent progress of palæontology know that this spirit of uniting palæontology ever more closely with distribution and palæogeography is that which constantly animates the older as well as many of the younger workers in this field.

Zoological methods—Zoology in the sense of studying extinct forms as living organisms is also becoming closer day by day, and we are now enjoying the recognition by mammalogists (Weber[1], Beddard[2]) of the absolute necessity of coupling the study of ancestral with that of the recent forms in all questions both of distribution and of classifica-

1 MATTHEW, W. D. *A Provisional Classification of the Freshwater Tertiary of the West.* Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 19-77.
2 OSBORN, H. F. *Faunal Relations of Europe and America during the Tertiary Period.* Ann. N. Y. Acad. Sci., vol. xiii, 1900, pp. 46-56.
3 OSBORN, H. F. *Theory of Successive Invasions of an African Fauna into Europe.* Ann. N. Y. Acad. Sci., vol. xiii, 1900, pp. 56-58.
1 *Die Saugethiere.* 8°, Jena, 1904.
2 *Mammalia.* The Cambridge Natural History, 8°, 1902.

tion. In connection with distribution our chief advance has been to determine the exact geographical location and chronological succession of animals, the local conditions of geological deposition in relation to habits and habitat or environment, as well as its bearing upon the study of past climates, or what may be called palæometeorology.

Adaptive radiation, continental—In connection with the comparison of mammals in their intercontinental as well as in their continental relations, the branching system of Lamarck and the divergence which impressed Darwin is perhaps most clearly expressed by the word "radiation"[3]. Elsewhere the conception of adaptive radiation has been fully developed in connection with the origin of certain orders[4].

It may here be briefly pointed out that Africa[5], South America, North America and Eurasia prove to have been the three chief geographical centres of ordinal radiation.

Adaptive radiation, local.[6]—Quite as important, although not carried on so grand a scale, is the local adaptive radiation which brings about a diversity of type in the same geographical regions and is the basis of the polyphyletic law of which we shall next speak. It is perhaps best illustrated by the Ungulates. In addition to (1) digital reduction (Kowalevsky) and (2) carpal and tarsal displacement (Cope, Osborn) in relation to the choice of harder and softer ground, there is recognized (3) after the primary conversion of semi-unguiculate into ungulate types, a reversed conversion of ungulate types into clawed types, as seen in ***Dichobune*** (Artiodactyla), ***Chalicotherium*** (Perissodactyla), and perhaps in an incipient stage in ***Agriochoerus*** (Artiodactyla); (4) secondary adoption of aquatic habits, as seen, for example, in the Amynodontidæ among the Rhinocerotoidea. Divergence by the above factors has long been recognized. There are also to be seen phyletic series combining in various ways either of the following eight conditions of foot,

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3 Osborn H F., *Rise of the Mammalia.* Proc. Amer. Association, Adv. Sci., vol. xlii, 1893, p. 215.
4 *Adaptive Radiation of Orders and Families* Ann. N. Y. Acad. Sci. vol. xiii. 1900, pp 49-51.
5 Ann. N. Y. Acad. Sci. xiii, 1900, pp. 56-58.
6 Osborn, H. F., *The Law of Adaptive Radiation.* Amer. Nat. xxxvi, 1902, pp. 353-363.

skull and tooth structure, which are not found to be necessarily correlated:

Primitive Condition.	Secondary Condition.
(5) Mesaticephaly	(6) Elongation (dolichocephaly) of skull (7) Abbreviation (brachycephaly) of skull
(8) Mesatipody	(9) Elongation (dolichopody) of limbs (10) Abbreviation (brachypody of limbs
(11) Brachyodonty	(12) Elongation (hypsodonty) of teeth

Law of correlation.—The bearing of these observations on Cuvier's law of correlation is to modify rather than to displace it. It may be restated as follows[1]: The feet (correlated chiefly with limb and body structure) and the teeth (correlated chiefly with skull and neck structure) diverge independently in adaptation respectively to securing (feet) and eating (teeth) food under different conditions; each evolves directly for its own mechanical functions or purposes, yet in such a manner that each subserves the other. Thus, for example, there is a frequent correlation between dolichocephaly, dolichopody and hypsodonty, as in certain of the *Equidae;* but there are so many exceptions to such correlation, because of the separate adaptive evolution of each organ, that it would be entirely impossible to predict the structure of the tooth from the structure of the claw; or vice versa.

Law of analogous evolution.—One of the most important advances of the past decade, for which the way was largely prepared, in the previous decade, by Scott's papers on *Oreodon*, *Poebrotherium* and *Mesohippus*, has been the clear recognition of this law. These phenomena give rise to an enormous number of analogies (homoplasies, parallelisms, convergences) not only of structure but of entire types, of families, and of groups, very confusing to the seeker of real phyletic relationship.

1 Osborn. Amer. Nat. xxxvi, 1902, p. 363.

Evolution in part determinate.—As regards the modes and factors of evolution[2], the continuous stages of evolution which we are securing among the horses, camels, rhinoceroses, and many other families, afford opportunities which have never been afforded before. We are with adaptive characters from their birth or genesis, through their prime, into their decline and death. Through this unique opportunity for observation has been confirmed a view of evolution long shared by most if not all palæontologists, vertebrate and invertebrate, but naturally not understood or

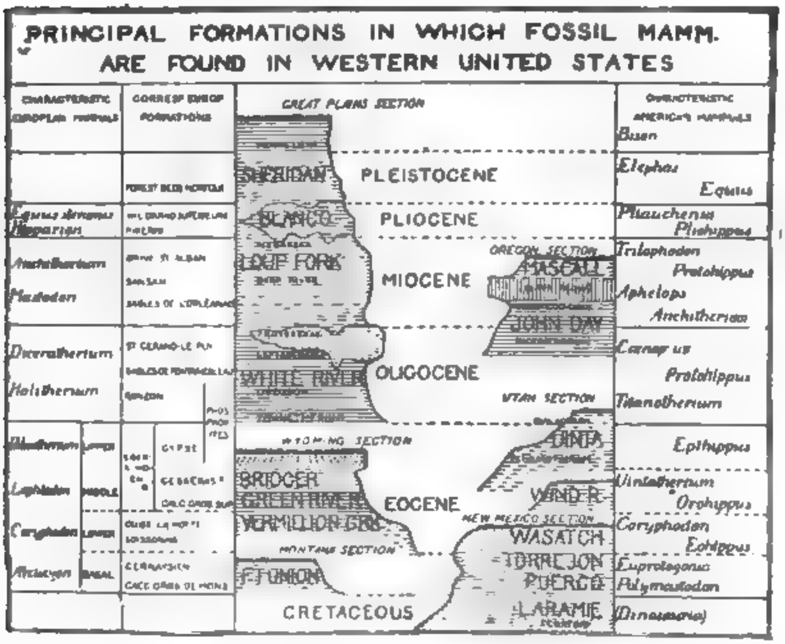

FIG 1

Most recent geological subdivision of the American Tertiary.

Showing that the successive sections in Montana, New Mexico, Wyoming, Utah, Oregon, and the Great Plains afford a complete history of the Tertiary, homotaxial with that afforded by the corresponding European formations.

shared by other zoologists because of the essentially different nature of evidence. I refer especially to the theory of

2 SCOTT, W B *On the Mode of Evolution in the Mammalia and on some of the Factors in the Evolution of the Mammalia.* Jour. Morphol. vol. v, 1891, No. 3, pp. 361-378, 378-402.

the definite or determinate origin[1] and development of certain at least of the new adaptive structures, apparently, but not certainly according to the principle to which Waagen applied the term mutation[2]. The mutation of the palæontologist, however, is quite distinct from the phenomena of minute saltations to which de Vries has applied Waagen's term in his valuable experiments[1].

Potential of similar evolution—In connection with analogous, but especially with partially determinate evolution, we not only have the similarly moulding influences of similar habits, and the action of the various factors of evolution[2] which we cannot stop to discuss, but clear evidence of the existence of a potential of similar evolution, a kind of latent homology which determines that when certain structures are to appear among animals independently derived from a common stock, they will appear at certain definite points and not at random. For example, the genesis of the rudiment of the horn in three independent phyla of Eocene titanotheres is at exactly the same point, namely, at the point of junction of the frontals with the nasals at the side of the face just above the eye.

The polyphyletic law.—Partly as an outgrowth of the synthesis of the above principles and partly as the result of new discoveries and the closer study of types already known is the full recognition of the polyphyletic law.[3] If we examine the phylogenies of Huxley and Cope, and even those of more recent writers (Scott, Osborn, Wortman) of a decade ago, we find that the attempt is made for example, to trace the pedigrees of the horses and rhinoceroses in a monophyletic manner. The first known instance of this kind was Huxley's pedigree of *Equus* through *Hipparion*, *Anchitherium* and *Palaeotherium*, all of which are now known to belong to entirely distinct phyla. Another instance was

1 OSBORN, H. F. *The Palaeontological Evidence for the Transmission of Accquired Characters.* Amer. Naturalist, vol. xxiii, 1889, p. 562.
2 SCOTT, W. B. *On Variations and Mutations.* Amer. Jour. Sci. vol. xlviii, Nov. 1894, pp. 355-374.
1 Elsewhere this profound difference between palaeontological mutations and the mutations of de Vries is carefully pointed out. See "OSBORN Present Problems of Palaeontology", address before St. Louis Congress of Science and Art, September, 1904, first printed in Popular Science Monthly, December, 1904.
2 OSBORN, H. F. St. Louis Address. *Loc. cit. supra.*
3 OSBORN, H. F. *The Perissodactyls typically, polyphyletic*, Science, N. S., vol. xvi, 1902, p. 715.

the comparatively recent effort to trace all rhinoceroses through the Oligocene *Aceratherium occidentale* Leidy as the stem form.

The polyphyletic law is an outgrowth of four different kinds of evidence. First, that the stem forms are very much older than we supposed them to be; we placed them in the Pliocene and Miocene, they have now been traced to the Oligocene and Eocene. Second, as a consequence of this, certain modern genera of mammals have their own ancestry, apart from that of closely related genera, as far back as the Oligocene and perhaps Eocene. The most conspicuaus example of this is the tracing back of the Dholes (genus *Cyon*) among the Canidæ, to an Oligocene form, showing that Cyon separated from *Canis* in the Eocene (Wortman and Matthew)[1]. Third the polyphyletic law is the result of local adaptive radiation or divergence apparently of habit either by choice or by necessity. For example, among the horses it separates off the grazing types (*Protohippus*), which are naturally progressive, from the browsing types (*Hypohippus*), which are naturally conservative, both found in the same locality (Fig. 4). It thus splits up animals living in a single region into a number of contemporaneous types or genera which may coexist throughout long periods; it is a *segregation*, functional rather than adaptive. Fourth, the polyphyletic law results from the invasion into a region of a generic or specific phylum which has evolved on another continent; for example, the Eurasiatic *Teleocera* came in among the American rhinoceroses in the Middle Miocene.

This polyphyletic law has now been demonstrated (Osborn[2]) among the rhinoceroses both of Eurasia and of North America, and is the key to the comprehension of this group; in Fig. 3 printed herewith it is shown that there are not only three families, namely, cursorial (Hyracodontidæ), aquatic (Amynodontidæ), and terrestrial (Rhinocerotidæ), but that the last family splits up into six and possibly seven phyla, many of which are contemporaneous; and the ten-

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1 *The Ancestry of Certain Members of the Canidae, the Viverridae, and Procyonidae* Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 139-148.
2 *Phylogeny of the Rhinoceroses of Europe.* Bull. Amer. Mus. Nat. Hist., vol. xiii, 1900, pp. 229-267.

dency of discovery will be to increase rather than to diminish the number of contemporaneous independent phyla. Similarly the Eocene titanotheres instead of forming a successive monophyletic series, divide into four distinct phyla, to each of which a generic name must be given. Similarly again, the lower Oligocene titanotheres[4], as shown in Fig. 7, divide into four phyla, three of which have been traced in successive stages from the bottom to the summit of the Oligocene, each giving off several collaterals, all living in the same region and found in contiguous beds, but probably having a slightly different local habitat and habits. The law is illustrated again, as shown in Fig. 4, both in the Oligocene and Miocene horses; in the Oligocene, for example, we have five contemporaneous lines of horses (Osborn[5], Gidley), one of which includes the classic *Mesohippus bairdi* of Leidy, which was long considered the single Oligocene horse, and figured as such in all phylogenies; in the Upper Miocene beside the *Protohippus* which still apparently is most nearly ancestral to Equus, we find as contemporaries, the browsing, forest-living *Hypohippus* and the grazing and highly cursorial *Neohipparion*. A comparison of the phylogeny of the Camelidæ (Fig. 5) published by Wortman[1] in 1898 on the monophyletic basis with that published by Matthew[2] in 1904 on the polyphyletic basis, shows the rapid progress which has been made in the demonstration of the polyphyletic law. Similar results are apparent from our preliminary studies of the Proboscidiae in America. Many able contemporary workers, especially Schlosser and Deperet, are also bringing forth new illustrations of this law in Europe.

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3 *New Miocene Rhinoceroses with Revision of Known Species.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 307-326.

4 *The Four Phyla of Oligocene Titanotheres.* Bull Amer. Mus. Nat. Hist., vol. xvi, Feb. 1902, pp. 91-109.

5 *New Oligocene Horses.* Bull. Amer. Mus. Nat. Hist., vol. xx, May, 1904, pp. 167-179.

1 *The Extinct Camelidae.* Bull. Amer. Mus. Nat. Hist., vol. x, 1898, pp. 93-142.

2 *Notice of two New Oligocene Camels.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 211-215.

Modern Fauna, Higher Placental Radiation.
Archaic Fauna, Lower Placental Radiation.

FIG. 2.

Extinction of the lower placental radiation of the Cretaceous, and sudden Introduction of the higher placental radiation of the Tertiary.

The orders Amblypoda, Condylarthra, Edentata, Creodonta, and earlier Primates disappear in North America. The comparatively modern Rodentia, Carnivora, Perissodactyla, Artiodactyla, and Proboscidea suddenly appear without known ancestors in the Lower Tertiary. No connections have thus far been traced between this older, archaic fauna and the newer fauna.

II. Progress of Discovery and the New Phylogenetic Problems Suggested Thereby.

My purpose in this section is to give a brief resumé of the progress during the past ten years, and in our present state of knowledge to point out where exploration and research should principally be directed.

The general advance has been made in five distinct lines, which appear to mark out also the main lines for future research. First, the biological value of more accurate geological records (Compare Fig. 1), has been recognized; as a result the mammalia have been chronologically segre-

gated into successive life zones similar to those which have long been developed in invertebrate, palæontology; these life zones in some cases subdivide not only the periods (Eocene, Miocene, etc.), but also subdivide the stages (Bridger, Unita), etc. Second, not only have these clearer chronological subdivisions been made, but the faunas have been separated according to their kinds and the nature of the deposits, into those which inhabited respectively the lowlands and rivers, forests, plains, and uplands. The advance of physiography has been felt, and by the careful work of Hatcher[1], Matthew[2], and Gidley[3], the theory of fluviatile, flood plain, and æolian deposits has tended to replace the theory of great lakes or lacustrine deposits. Third, there has accordingly been brought about a modification of our views as to the meteorological or climatic phases of the Tertiary period, in the direction of extending the idea of the existence of great dry plains with drifting sands favorable to Aeolian deposits chiefly in the Lower Pleistocene, Pliocene and Miocene; we speak less of a moist, subtropical, and more of a drier climate. Fourth, the zoogeographical relations of the North American faunas to those of other continents have become much more clearly understood (Osborn[6]) in connection with more exact geological records not only by the addition of many new forms from the Eurasiatic radiation hitherto unknown, but also by observing more precisely the time of arrival of Eurasiatic migrants in the Lower, Mid- and Upper Miocene and of South American in the Pleiocene. Fifth, the phylogenetic succession has become much clearer and more direct, although a vast amount remains to be done. The separate branches of the mammalian phyletic tree have been successfully traced back farther and farther toward the beginnings of the Tertiary,

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1 *Origin of the Oligocene and Miocene Deposits of the Great Plains* Proc. Amer. Philos. Soc., xli, No. 169, Apr. 1902.

2 *Is the White River Tertiary an Aeolian Formation* Amer. Nat., xxxiii, May, 1899, pp. 403-408.

3 *Fossil Mammals of the Tertiary of Northeastern Colorado,* Mem. Amer. Mus. Nat. Hist., vol. 1, pt. vii, Nov. 1901.

4 *The Freshwater Tertiary of Northwestern Texas.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 617-635.

5 MATTHEW and GIDLEY. *New or Little Known Mammals from the Miocene of South Dakota.* Bull. Amer. Mus. Nat. Hist., vol. xx, pp. 241-265.

6 *Faunal Relations of Europe and America.* *Science,* vol. xi, April, 1900, pp. 461-514.

with resultant changes in our classification. Perhaps the most signal taxonomic result of this phylogenetic progress is in the clear definition of certain genera, notably among the rhinoceroses (Osborn[1], Thomas[2]), as shown in Fig. 3; it has proved to be absolutely necessary for the sake of clearness to recognize a number of genera which many systematists (Flower, Lydekker) have considered simply synonyms of the genus *Rhinoceros*. Sixth, the chief morphological result is the discrimination of sexual characters, especially among the male and female forms[3], which in many cases by Marsh and Cope had been considered as distinct species. The recognition (Osborn[4]) that progressive dolichocephaly and brachycephaly profoundly modify all the characters of the skull and the teeth on the principle of correlation, also represents a morphological advance.

The independent and more or less cooperative field or museum work of Scott, Osborn, Wortman, Matthew, Hatcher, Douglass, Gidley, Peterson, has been instrumental in fordwarding these chief lines of progress.

The Older Mesozoic Fauna.

Unfortunately the efforts of the American Museum to find more of the Protodonta (*Dromotherium*, *Microconodon*) from the Upper Trias or Rhætic have proved unavaliing. The relation of these animals to the Theriodont reptiles has been suggested (Seeley), but the single bone of the jaw rather sustains their relation to the mammalia. The groove on the inner side of the jaw of all Mesozoic and some recent mammals is now recognized as the Meckelian-cartilage groove (Bensley[5]).

In the Upper Jurassic or Lower Cretaceous mammalia of the Como beds we must also admit that no progress has been made to determine whether these animals represent both Insectivora and Marsupialia and perhaps Monotremata (Osborn), or whether they are all Marsupialia[1] (most Eng-

1 *Phylogeny of the Rhinoceroses of Europe.* Bull. Amer. Mus. Nat. Hist., vol. xiii, 1900, pp. 229-267.

2 *Notes on the Type Specimen of Rhinoceros lasiotis Sclater with Remarks on the Generic Position of the Living Species of Rhinoceros.* Proc. Zool. Soc., Lond., June 4, 1901, pp. 154-158.

3 *The Cranial Evolution of Titanotherium.* Bull. Amer. Mus. Nat. Hist., vol. viii, 1896, pp. 157-197.

4 *Dolichocephaly and brachycephaly in the Lower Mammals.* Bull. Amer. Mus. Nat Hist., vol. xvi, 1902, pp. 77-89.

5 *On the Identification of Meckelian and Mylohyoid Grooves.* Univ. of Toronto Studies Biol., Ser. 3, 1902, pp. 75-81.

lish authors). A re-study (Osborn[2]) of the structure of the upper molars in the Yale Museum collection strengthens the tritubercular theory (Cope, Osborn) of the origin of the upper molar teeth.

The Upper Cretaceous Fauna.

Here again the relatively modernized (Osborn[3]) animals of the Upper Cretaceous or Laramie, although carefully revised, still require elucidation from the rich collection in the Yale University Museum. Marsh's statement that certain of these animals are Marsupials has been fully confirmed by Matthew, a fact which is striking in the absence of any present evidence of Marsupials in the American basal Eocene.

The present relations of these Laramie animals to those of the Basal Eocene (Puerco, Torrejon has been somewhat strengthened by the recognition of the ancestors (***Meniscoessus***) of *Polymastodon* also by the supposed recognition of forms related to the Amblypoda, especially to the Periptychidæ (Osborn); but forms certainly ancestral to the Creodonta and other Eocene mammals have not yet been recognized.

The Basal Eocene Fauna.

In this fauna, commonly known as Puerco, great progress has been made

Two sharply defined faunal stages have been distinguished (Wortman), a lower, Puerco proper, and an upper, Torrejon (Matthew[4]), (Compare Fig. 1, 2). The latter is more nearly contemporaneous with the Basal Eocene (Cernaysien) of France. Fortunately, in Montana, a new locality has been discovered for these very archaic mammals in the Fort Union beds (Douglass[5], Farr) which promises to extend our knowledge of this fauna.

The zoogeographical relations of this fauna, already established by some parallels with the Cernaysien of

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1 Ameghino, Fl. *Los Diprotodontes del orden de los Plagiaulacideos.* An. Mus. Nac., Buenos-Aires, t. ix, 1903. pp. 81-192.

2 *Palaeontological Evidence for the Original Tritubercular Theory.* Amer. Jour. Sci., vol. xvii, April, 1904. pp. 321-323.

3 *Fossil Mammals of the Upper Cretaceous.* Bull. Amer. Mus. Nat. Hist., vol. v, 1893, pp. 311, 330.

4 Matthew. *A Revision of the Puerco Fauna.* Bull. Amer. Mus. Nat., Hist. vol. ix, 1897 pp. 260-261

5 *A Cretaceous and Lower Tertiary Section in South Central Montana.* Proc. Amer. Phil. Soc., vol. xli, 1902, No. 170, pp. 207-224.

France, have been perhaps extended by discovery of the Notostylops beds in Patagonia (Ameghino[1]). Faunal unity with the extremity of South America if confirmed will be of great significance; it appears to be probable but perhaps not absolutely demonstrated.

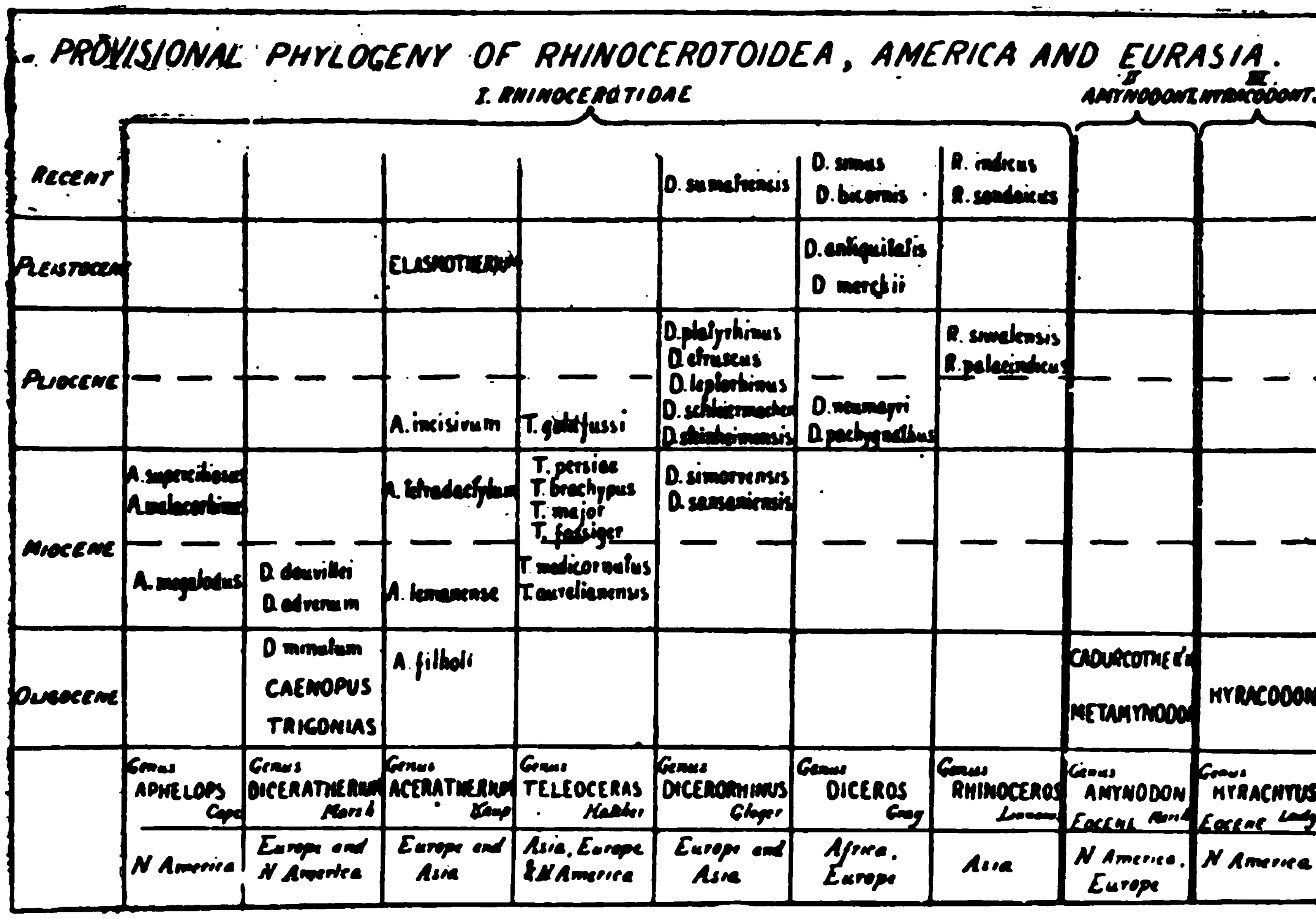

FIG 3.

The Polyphyletic Law Illustrated in the Rhinoceroses.

The Rhinocerotoidea early divided into the *Hyracodontidae* ' (iii), known only in America, Amynodontidae (ii), known in America and Europe, and the *Rhinocerotidae* (i) The last family of true rhinoceroses prove to include at least seven distinct phyla corresponding to seven genera which extend back as far as the Middle Miocene if not into the Oligocene.

The most important single phylogenetic result is the strong evidence which has been brought forward for the ancestral relationship of the Tæniodonta (Ganodonta) of the Torrejon to the Gravigrade Edentata (Wortman[2]), borne out by careful comparison of many parts of the skeletons of Psittacotherium and allied forms with those of the gravigrade sloths. Indirect proof of the early existence of

1 *Quadro Sinoptico de las formaciones terciarias y cretaces de la* Argentina. An. Mus. Nac. d. Buenos-Aires, t. viii, Julio, 1902.
2 *The Ganodonta and their Relationship to the Edentata* Bull. Amer. Mus. Nat. Hist., vol. ix, 1897, pp. 59-110.

Edentates in North America has come to hand in the discovery of Dasypoda in the Middle Eocene (Osborn[1]).

Another observation which may prove to have very broad phylogenetic bearings is the evidence of arboreal ancestry in the structure of the feet of the Creodonta, Condylarthra and Amblypoda (Matthew); it has not yet been ascertained whether this evidence is of the same nature as that which exists in the feet of the Marsipials (Huxley, Dollo, Bensley). With this exception attempts to bring these essentially archaic Placentals nearer to the Marsupials have not been successful.[2] The single direct link with the higher Placentals which has even been alleged to occur in these beds is the supposed ***Viverravus*** of the Torrejon. The opinion has therefore been expressed (Osborn[3]) that these animals should be sharply separated from the higher placentals and placed in the Meseutheria.

Among the unsolved problems in this Basal Eocene fauna is also its source, or ancestry, which has only in part been traced into the Cretaceous fauna. We require fuller evidence as to the relationship with the ***Notostylops*** fauna of Patagonia (Ameghino), also a positive demonstration that the Tæniodonta are really ancestral to the Edentata. In other words, the phylogenetic connections of these Basal Eocene Placentals of North America and Europe are circumscribed; the sanguine view of Cope that they contain the sources of the modern Placentals which first appear in the Lower Eocene has not been realized; none of these animals give us the stem forms of the true Carnivores, Perissodactyls or Artiodactyls of the Lower and Middle Eocene.

LOWER, MIDDLE AND UPPER EOCENE FAUNAS

The chief geological and faunal progress has been in the Bridger (Bartonien) and Uinta (Ligurien) stages, corresponding to the Middle and Upper Eocene, which have at last been clearly and sharply divided into two successive faunal stages for the Bridger (Matthew, Granger), and two successive faunal stages for the Uinta (Peterson, Osborn). The importance of these divisions in the evolution of the

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1 *An Armadillo from the Middle Eocene (Bridger) of North America.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 163-165.

2 WORTMAN. *Studies of Eocene Mammalia in the Marsh Collection.* Part I, Carnivora. Amer. Jour. Sci., vols. xi-xiv, 1901, 1902.

3 *A Division of the Eutherian Mammals.* Trans. N. Y. Acad. Sci., June 4, 1894, p. 234.

Primates, Carnivores and Perissodactyls can hardly be overestimated.

At the same time the zoogeographical relationships of our Lower Eocene (Soissonien) have been extended by the discovery of a French Creodont (*Palæonictis*) in America and of an American Creodont (*Pachyaena*) in France. Still more surprising and important is the discovery[1] in the Middle Eocene of Dasypoda (*Metacheiromys*), armadillos with canine teeth and with provision for a stout leathery if not osseous carapace. This absolutely establishes the Cretaceous if not Basal Eocene zoogeographical relations of North and South America, and adds another fact to the growing evidence that North and South America were related in the Mid-Cretaceous and perhaps Early Tertiary and then separated again until the Pliocene.

Our phylogenetic results have been mose encouraging in some directions and most baffling in others. Still more striking than ever before is the fact that the Lower and Middle Eocene fauna of Perissodactyla, Artiodactyla, Carnivora, Cheiroptera, Monkeys, and true Rodents, an essentially modern fauna, is without any known direct affiliation with the Basal Eocene fauna (Meseutheria) (Compare Fig. 2). Mingled with this essentially modern fauna are the numerous survivors of the archaic fauna, namely, the Creodonta, Condylarthra, Amblypoda, with which should certainly be reckoned the Edentata (Paratheria, Thomas) and probably the Insectivora.

The phylogenetic successions of the families within these archaic orders have been much more clearly traced, namely, the pedigree and adaptive radiation of the Creodonts into specializations of various kinds[2]. Among the Amblypoda the law of long-skulled and short-skulled phyla has again been found to prevail, in proof that the genera about which there was such a heated discussion, namely, *Tinoceros* as a relatively short-skulled form and *Loxolophodon* as a relatively long-skulled form, really represent two valid and distinct phyla.

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1 OSBORN, H F *An Armadillo from the Middle Eocene (Bridger) of North America.* Bull Amer Mus Nat Hist vol xx, 1904, pp. 163-165.

2 MATTHEW, W. D. *Additional Observations on the Creodonta* Bull. Amer Mus Nat. Hist, vol xiv, 1901, pp. 1-38.

Among the modernized Placentals, we have added nothing to our knowledge of the supposed Cheiroptera. An important step is the proposed transfer to the Insectivora of the genus *Hyopsodus* which has long figured among the Primates (Wortman[3]), a relationship which will be settled by material now in our possession. Among the remaining undoubted Primates (Osborn[4]) there is the series of Anaptomorphidæ which still resemble the Tarsiidæ more than any of the other lemurs, or true monkeys, although their actual relationships are absolutely undetermined. The second family of Primates, represented by the Notharctidæ (*Notharctus* and *Limnotherium*) and other forms, has been placed near the South American Cebidæ by Wortman[1], but this also requires the confirmation or disproof which will soon be forthcoming; if South American relationships are established for these Primates, a very much mooted problem will be solved.

Among the Perissodactyla the Titanotheres (Osborn[2]) have split up into four phyla, one of which (*Palaeosyops*) died out, while the three remaining phyla independently acquired rudimentary horns (*Telmatotherium*, *Manteoceras* *Dolichorhinus*) and apparently gave rise to the evolution of the four phyla of great Oligocene titanotheres. Among the Artiodactyla the rare Middle Eocene forms still require elucidation, but the Camelidæ have been traced definitely into the diminutive Upper Eocene (Uinta) *Protylopus* (Scott[1], Wortman[2]). Two distinct phyla of Oreodontidæ have also been traced back in the Upper Eocene into the genera *Protagrichoerus* and *Protoreodon* (Scott). Among the enemies of these animals, the Canidæ have been traced into the Upper Eocene genera *Prodaphaenus* and *Uintacyon* and Marsh's Middle Eocene *Vulpavus* has also proved to be a member of the true Canidæ, although, its relationships

3 *Studies of Eocene Mammalia.* Part II, Amer. Jour. Sci., vol. xv, May, 1903, p. 401.

4 *American Eocene Primates*, etc. Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 169-214.

1 Wortman. *Op. Cit.*, Amer. Jour. Sci. vol. xv, 1903, pp. 409-411.

2 *The Four Phyla of Oligocene Titanotheres.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 91-109.

1 *The Selenodont Artiodactyls of the Uinta Eocene.* Trans. Wagner Free Inst. Sci. Phil., vi, 1899, p. 100.

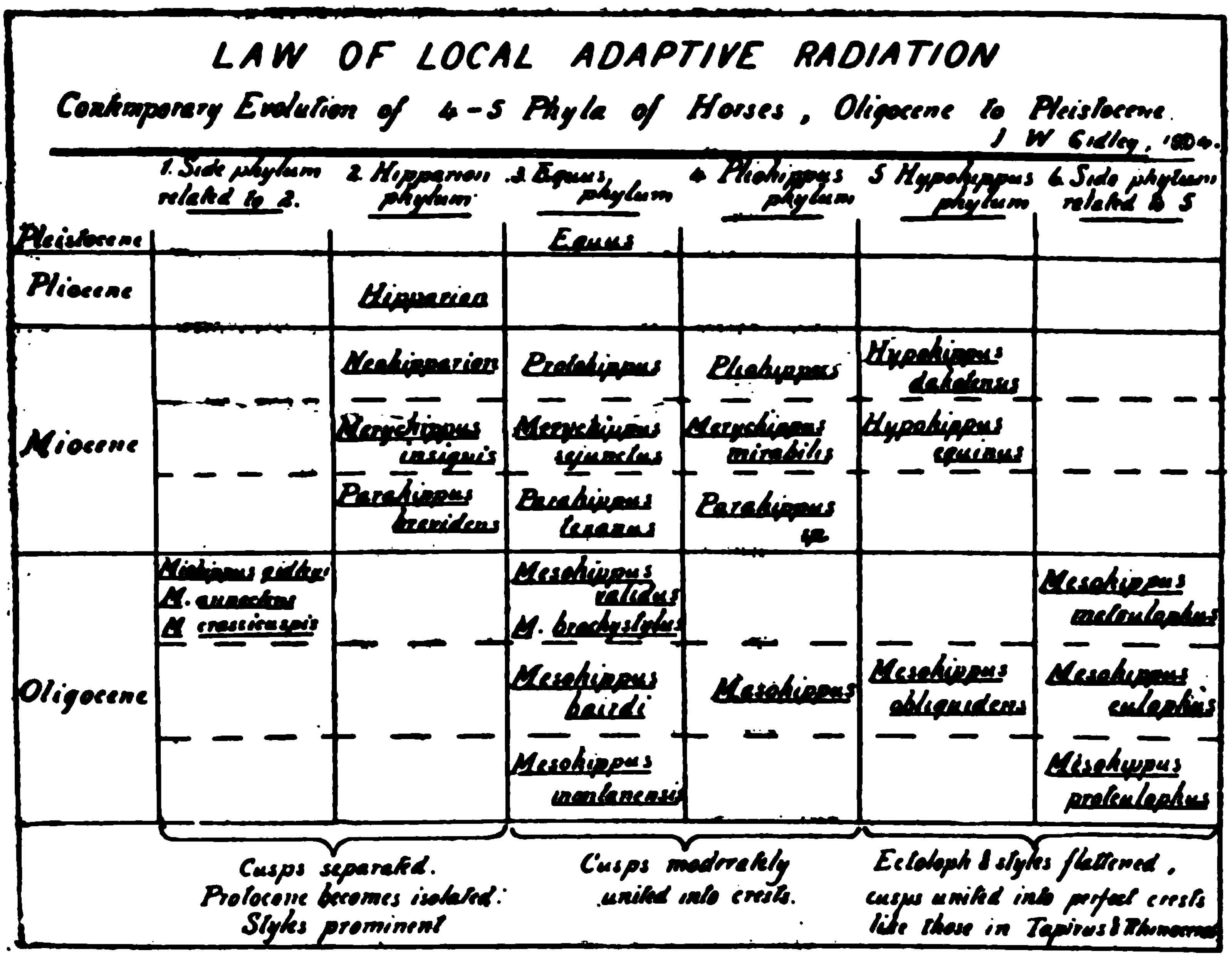

FIG. 4.

The Polyphyletic Law Illustrated in the Evolution of the Equidae of North America

In the Miocene are at least four contemporary phyla of horses, the extremes being represented by the forest-living horse *Hypohippus*, and the light-limbed Neohipparion; the central form, *Protohippus*, apparently leading to *Equus*.

This true *Equus* line separated off from other horses as far back as the base of the Oligocene. In this period again five distinct contemporary phyla have already been found.

are not exactly determined (Wortman, Matthew). The supposed ancestry (Wortman) of the Felidæ in the Eocene in the problematical genus *Aelurotherium* has been disproved (Matthew).

Still undiscovered or unrecognized in the Eocene both of America and Eurasia are the ancestors of the true Rhinocerotidæ which suddenly appear in the Oligocene. The Basal Eocene ancestry of the Rodentia is still satisfied only provisionally by the family Mixodectidæ, belonging to the somewhat hypothetical Proglires (Osborn[3]); the teeth seem to be approaching those of the Rodents but knowledge of

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2 *The Extinct Camelidae* Bull. Amer. Mus. Nat. Hist., vol. x, 1898, pp. 93-142.

3 Bull. Amer. Mus. Nat. Hist., xvi, 1902.

the skeleton is necessary to determine whether they may not after all be remotely related to the Lemurs (order Cheiromyoidea) as Cope and Wortman have suggested. Wortman is strongly of the opinion that the Eocene Primates (Notharctidæ, Anaptomorphidæ) are not Lemuroidea, and that the former family are distinctly South American; this also requires confirmation.

Search for the exact relations and points of connection between the Carnivora and Creodonta, has thus far been entirely without definite success; in other words, the true Carnivora seem to be as separate from the Creodonta as the true Perissodactyla are from the Condylarthra.

As regards the Artiodactyla, as yet very little is known of the Middle and Lower Eocene stages, among which it is especially important to test the truth of Scott's[4] broad generalization that the American Artiodactyla should all be regarded as affiliated to the Tylopoda as a stem group from which not only the Camelidæ evolved but also the other distinctively American Artiodactyls, such as the Oreodontidæ, and that even the traguloid forms are of tylopodous affinity and merely parallel or analogous to the true Tragulines of Eurasia. There is no doubt that such an adaptive radiation from a Tylopod stem is possible and that there is considerable actual evidence for it in the morphology of the skull of these various distinctively American Artiodactyls; but the hypothesis is such a bold one that we must wait for more material.

The chief problem of all, which is also the problem of the European palæontologists, is the source and origin of the modern Lower Eocene fauna as a whole, namely, the Carnivora, Perissodactyla, Artiodactyla, Primates, and Rodentia.

American Oligocene Faunas

Our Oligocene (Lower Oligocene Infra-Tongrien, Middle Stampien, and Upper Aquitanien, of Europe) has been the most thoroughly explored of any of the periods, owing to the richness of its fossil fauna.

The chief geological result is the separation of the

4 *The Selenodont Artiodactyles of the Uinta Eocene*: Trans. Wagner Free Inst. Sci. Phil., vi, 1899, p. 100.

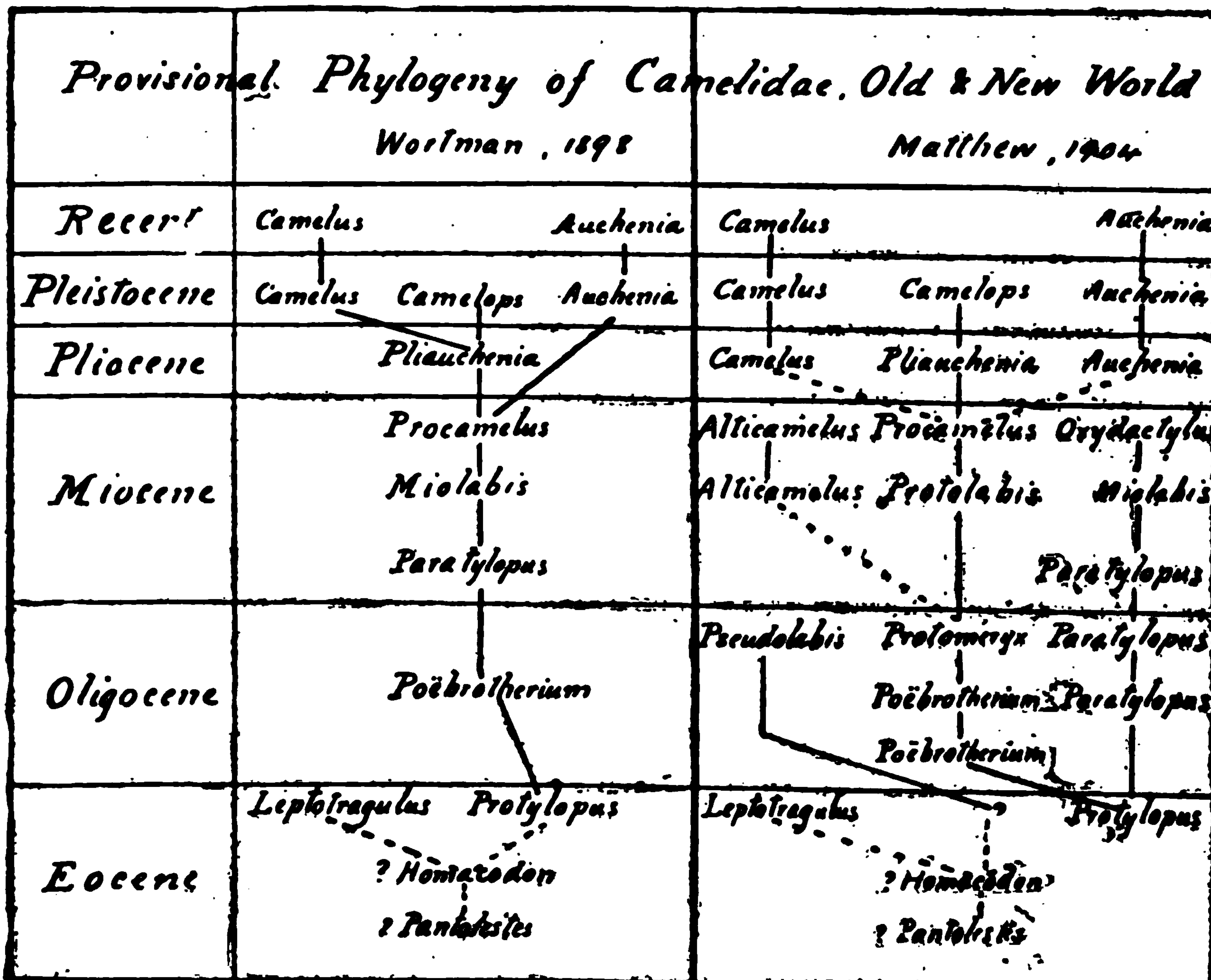

FIG. 5.

The Polyphyletic Law and Local Adaptive Radiation Illustrated in the Phylogeny of the Camels.

On the left is illustrated the older monophyletic view held as recently as 1898; on the right, the newer polyphyletic view developed in 1904 showing three distinct contemporary lines of Camelidae.

fluviatile or channel beds, with chiefly lowland or bottom fauna, from æolian or backwater sediments, chiefly with a plains and cursorial fauna. The three subdivisions originally observed by Hayden and Leidy are thus divided as follows:

I. Fluviatile or Channel Beds.	II. Æolian or Backwater Sediments.
Upper, Protoceras beds..........	..Leptauchenia beds.
Middle, Metamynodon beds.......	.Oreodon beds.
Lower, Titanotherium beds.	

This separation was chiefly brought about by Matthew's careful analysis of the animals coming from these respective

beds, the former (I) including lowland, forest and river-bottom, and aquatic animals, the latter (II) the animals of the plains and uplands. The John Day beds of Oregon apparently contain an overlapping fauna partly equivalent to the Upper Oligocene and partly to the Lower Miocene.

The already well known (Cope, Filhol) and close zoogeographical relationships during the Oligocene of North America and Europe are strengthened by the discovery of European Anthracotheriidæ, Mustelidæ (*Bunaelurus*[1]) and Erinaceidæ (*Proterix*, Matthew[2]) in America, and of the American Titanotheriidæ in Europe[3]. This leaves as the chief families in Europe still unknown in America the Palæotheriidæ, Anoplotheriidæ, Tragulidæ.

Our faunal knowledge has been especially enriched by the discovery and description of the hitherto unknown microfauna of the Titanotherium beds (Douglass[4], Matthew[5]) which includes archaic, *Centetes*-like forms, as well as *Erinaceous*-like forms.

The main phylogenetic results are the following. The Creodonta have been definitely traced to their extinction in the Hyænodontidæ (Table II). Among the Canidæ the ancestral line of *Cyon* (Dholes) has almost certainly been recognized in this period in the genus *Temnocyon* (Wortman and Matthew[6]) (Fig. 6). No trace of Edentata has been found, the forms formerly described as such now being known to be the peculiar Chalicotheriidæ, probably of Perissodactyl affinities. The rhinoceroses have been traced back in the Lower Oligocene to animals (*Trigonias*) with several incisors as well as with canine teeth (Osborn[1], Lucas[2]).

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1 MATTHEW, W. D. *On the Skull of Bunaelurus.* Bull. Amer. Mus. Nat. Hist., xvi, 1902, pp. 137-140.

2 *A Fossil Hedgehog from the American Oligocene* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 227-229.

8 TOULA. *Ueber neue Wirbelthierreste aus dem Tertiar Oesterreichs und Rumeliens,* Zeitschr. d. Deutsch. geolog. Ges., Jahrg. 1896, pp. 922-924.

4 *Foss. Mamm. White River.* Trans. Amer. Philos. Soc, n. s., vol. xx, 1901, p. 1-42.

5 *The Fauna of the Titanotherium beds.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 197-226.

6 Bull. Amer. Mus. Nat. Hist., vol. xii, 1899, pp. 139-148.

1 *The Extinct Rhinoceroses.* Mem. Amer. Mus. Nat. Hist., vol. i, 1898, pp. 75-165.

2 *A New Rhinoceros, Trigonias Osborni.* Proc. U. S. Nat. Mus. xxiii, No. 1207.

The law of local adaptive radiation with its polyphyletic consequences has completely altered our conception of several Oligocene families, as follows. The Titanotheriidæ (Osborn[3]) break up into four genera, which evolve independently from the base to the summit of the Oligocene, namely, *Titanotherium*, *Megacerops*, *Symborodon*, and *Brontotherium;* divergence is indicated by dolichocephaly and brachycephaly as well as by other characters (Fig. 7). Similarly the Equidæ break up into four and possibly five distinct contemporary phyla, and it now begins to appear probable that the line giving rise to Equus, separated off from the other horses as early as the Lower Oligocene (Osborn, Gidley; Fig. 4). The Oreodontidæ, represented by two phyla in the Upper Eocene, now present three phyla, namely, *Agriochoerus*, *Oreodon*, *Leptauchenia* (Matthew). Three phyla of Camelidæ are also recognized, namely, those represented by *Paratylopus*, *Poebrotherium*, and *Pseudolabis* (Matthew, Fig. 5). Similarly among the Felidæ, the Machærodont division, the only felines represented in America at this time, breaks up into the stout-limbed *Hoplophoneus* series ancestral to *Machaerodus* and *Smilodon* the slender-limbed *Dinictis* [4], and a third series represented by *Nimravus* (Fig. 6).

Among the gaps in the Oligocene is the entire absence of Primates, the genera *Laopithecus* and *Menotherium*, formerly associated with the Primates, proving to be singularly primitive tritubercular Artiodactyls. An important problem is the actual relationships of the Artiodactyl genera *Protoceras*, *Leptomeryx*, *Hypertragulus*, and *Hypisodus*, which according to Scott's theory above alluded to, represent with the Oreodontidæ an independent radiation of American Artiodactyla wholly without affinity with the European Tragulines.

The Miocene Fauna.

In our Miocene, equivalent to the Langhien (Orléanais), Helvétien (Sansan, Simorre), and Tortonien (Grive St. Alban, Bamboli) stages of Europe, the most exceptional pro-

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3 Bull. Amer. Mus. Nat. Hist., xvi, 1902, pp. 91-109.
4 Matthew. *Fossil Mammals of the Tertiary of Northeastern Colorado* Mem. Amer. Mus. Nat. Hist., vol. i, pt. vi, 1901.

gress has been made in the distinction of the geological and faunal zones. Ten years ago the accurate geological observations of Hayden were overlooked, and it was believed that formations equivalent to the Middle and Lower Miocene of Europe were sparsely if at all representetd. Now three faunal stages are clearly recognized (Scott[1], Matthew[2], Gidley[3]), namely: Lower (Rosebud beds), in which the animals are still sparsely known, Middle (Deep River beds), in which the fauna is becoming more fully known, Upper (Loup Fork beds), in which a very rich fauna is now fully known. Each of these divisions is distinguished by specific stages in the evolution of the horses, rhinoceroses, camels, oreodonts, rodents, and carnivores. These chronological successions derived from geology have already yielded very important new biological results.

The zoogeographical relationships with Europe have been strengthened by the discovery for the first time of ***Dinocyon*** (Matthew[1]), of a new species of rhinoceros (*Teleoceras bicornutus*[2] Osborn), closely similar to the *Teleoceras aurelianensis* of the Lower Miocene of France, by the recognition of new Mustelidæ (Lutra), and of the Castoridæ (*Dipoides*). The Proboscidea, now known to be of African origin, are not certainly found in the lower and sparsely known in the middle, but are fully represented in the upper beds. In the middle beds appears *Mastadon productus*, rather derivable from the *Palaeomastodon* of Africa than from the *M. angustidens* of France.

Our views as to the Miocene climate have also undergone a change, owing to the recognition that most of these deposits are fluviatile and æolian rather than lacustrine (Matthew, Gidley[3]), as evidence of a dry climate, marshy

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1 *The Mammalia of the Deep River Beds*. Trans. Amer. Philos. Soc., xviii, 1895, pp. 55-185.
2 *Foss, Mamm.* of the Tertiary, etc. Mem. A. M. N. H., vol. i, 1901.
3 *New or Little Known Mammals from the Miocene*. Bull. Amer. Mus. Nat. Hist., xx, 1904, pp. 241.
1 *A Skull of Dinocyon from the Miocene of Texas*. Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 129-136.
2 *New Miocene Rhinoceroses*. Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 307-326.
3 *New or Little Known Mammals from the Miocene of South Dakota* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 241-268.

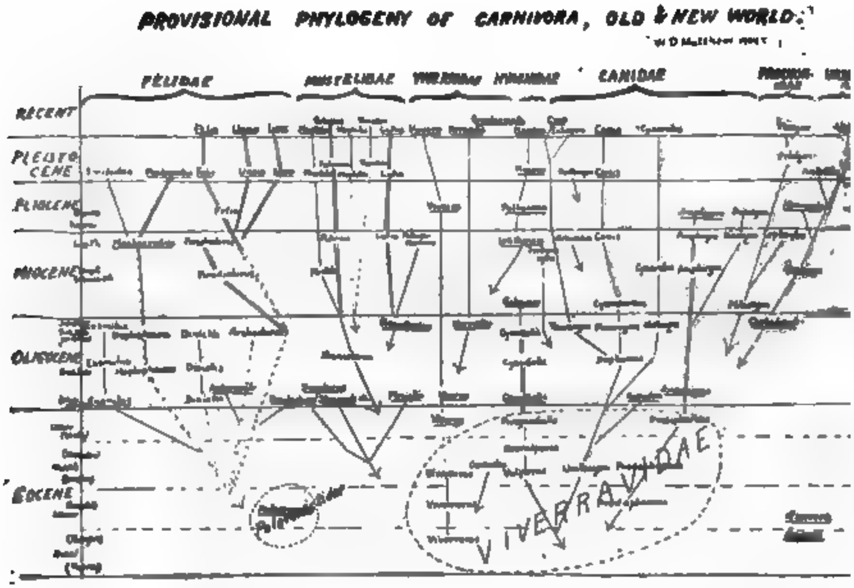

FIG. 6.

The hypothetical phylogeny of the Carnivora illustrating especially the great antiquity of some of the modern genera of dogs, such as *Cyon*, which separated off from the other Cranidae in the base of the Oligocene if not in the Eocene. This table includes also the European Carnivora and is of a temporary value *Palaeonictis*, although a Creodont may possibly be related to the Felidae.

plains, and drifting sands, rather than of the moister climatic conditions inferred from the older lake basin theory.

Among the chief phylogenetic results are the addition of at least four kinds of Canids (Fig. 6) and the tracing back of the Procyonidæ to the Lower Miocene *Phlaocyon* (Matthew[4]), tending to unite this phylum more closely with the Canidæ. The Mustelidæ are now represented by *Mustela* and *Lutra*. The Viverridæ and Ursidæ are still wholly unrepresented in America although evolving contemporaneously in Europe. Among the distinctively American Artiodactyls the Cervidæ are now recorded in the Middle Miocene (*Palaeomeryx*), a fact however still requiring confirmation. In this connection should be mentioned the discovery of the full characters of the genus *Merycodus* (*Cosoryx*),

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4 *Foss. Mamm* of the Tertiary, etc. Mem. A. M. N. H., vol. i, 1901.

which with *Blastomeryx* as the new family Merycodontidæ has been regarded by Matthew[5] to be more nearly related to the American Antilocapridæ than to the European Cervidæ, although its deerlike horns certainly suggest Cervine relationships. The Camelidæ until recently considered monophyletic have been shown to be in a marked degree polyphyletic[6], the Lower Oligocene *Paratylopus* giving rise to two phyla, one of which includes the "giraffe camel," *Alticamelus* (Matthew[1]), which presents a remarkable analogy in the elongation of its neck and limbs with the giraffes of Africa; similarly *Proebrotherium* splits into three phyla (Fig. 5, Matthew). Similarly the Oreodont, and Agrichœrine phyla have disappeared without leaving successors. The rival cursorial Hyracodontidæ and aquatic Amynodontidæ having died out, the true Rhinocerotidæ (Fig. 3) split up into three series, one including the extremely long-skulled and long-limbed types, possibly related to the true *Aceratherium incisivum* of Europe, a second including excessively broad-skulled types (genera *Aphelops* and *Peraceras* Cope), and a third including the short-footed (brachypodine) types (*Teleoceras*), almost certainly of European origin. The Tapiridæ are still sparsely known. The aberrant Chalicotheriidæ terminate in an Upper Miocene species which nearly equals in size the Lower Pliocene *Ancylotherium* of the Pikermi. The most astonishing discovery among the Rodentia is that of a member of the Mylagaulidæ with a very large horn core on the front portion of the skull (genus *Ceratogaulus* Matthew[2]).

The principal work still to be done in our Miocene is the following: to ascertain more fully the character of the Lower Miocene fauna, which is still unknown; to fix the date of the arrival of the earliest Proboscidea either early in the Middle or in the Lower Miocene; to trace the ancestry of the typical dogs; to ascertain the origin of the Cervidæ, which will probably prove to be Asiatic, as well as the origin of the peculiarly American Antilocapridæ.

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5 *A Complete Skeleton of Merycodus.* Bull. Amer. Mus. Nat. Hist., vol. xx, 1904, pp. 101-129.
6 *Notice of Two New Oligocene Camels.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 617-635.
1 *Foss. Mamm. of the Tertiary, etc.* Mem. A. M. N. H., vol. I, pt. vi, 1901.

The Pliocene Fauna.

Equivalent to Messinien (Pikermi), Plasancien (Casino), Astein (Rousillon), Sicilien (Val d' Arno sup.)

Our limited American Pliocene fauna still stands in sad contrast to the rich succession of Pliocene mammals of Europe. The Palo Duro mammals which Cope included in the Pliocene have proved to be Upper Miocene. Recent geological and palæontological work (Gidley[3]) shows that the only true Pliocene formation and locality is that of the Blanco beds of Texas, 75 feet in thickness, as against the rich successive Pliocene series of Europe. Nor are any species of *Equus* found here, as Cope supposed, and as might be expected from the presence of *Equus* (*E. stenonis*) in the Upper Pliocene of Europe. The chief faunal distinctions are the entire disappearance of the Rhinocerotidæ and the appearance of South American Mammals.

The zoogeographical changes are well known to enter a new relation by the invasion of the South American Edentata, namely, *Glyptodon*, *Megalonyx*, *Mylodon*. Among these a new Glyptodont, *Glyptotherium texanum* has recently become known (Osborn[1]) from a nearly complete carapace and partial skeleton, which exhibits primitive affinities with the Eocene types of Patagonia. Among the Proboscidea the Stegodont stage appears in the so-called *Mastodon mirficus* of Leidy, indicating a late Pliocene age for the Blanco formation. In the marine Miocene of Japan (Iwasaki and Yoshiwara[2]) the remarkable discovery has been made of an anomalous skull representing a new family (*Desmostylidae* fam. nov.) either of hypsodont Sirenia or of Proboscidea, and Merriam[1] has recognized as a similar form occurring on the coast of California the genus *Desmostylus* first noticed by Marsh.

The phylogenetic series is all too limited, the horses

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2 *A Horned Rodent.* Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 291-310.

3 *The Freshwater Tertiary of Northwestern Texas.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 617-635.

1 *Glyptotherium texanum* Bull. Amer. Mus. Nat. Hist., xix, 1903, pp. 491-494.

2 *Notes on a New Fossil Mammal* Jour. Coll. of Sci. Imp. Univ. Tokyo, vol. xvi, Art. 5, 1902.

1 *Science*, n. s., vol. xvi, Oct. 31, 1902, p. 714.

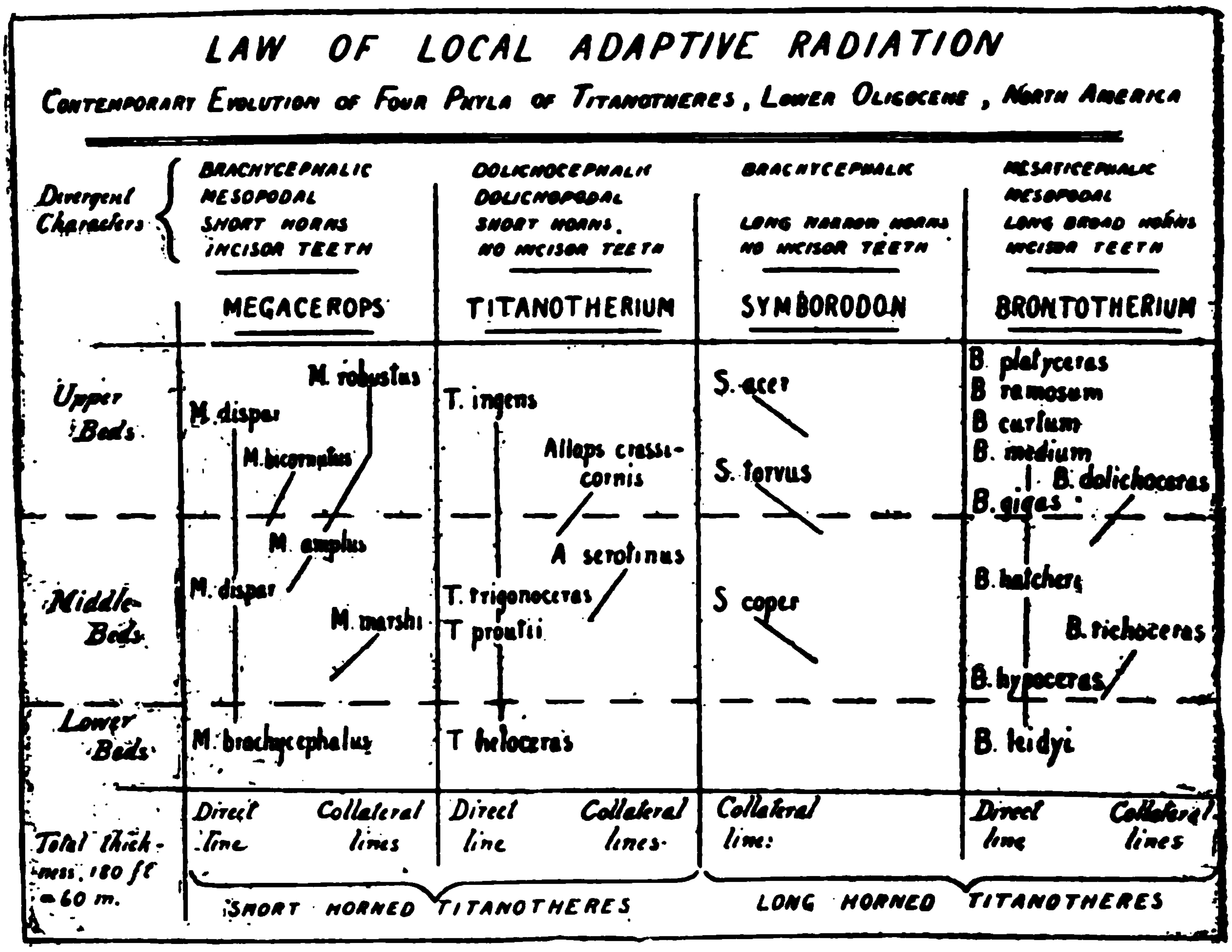

FIG. 7.

The law of local adaptive radiation illustrated in the four phyla of Oligocene Titanotheres, one or more of which gave off collateral branches.

Three of these phyla have now been shown to have a separate origin in the Middle Eocene.

being sparsely represented by species of *Neohipparion* (Gidley [2]) and a doubtful *Pliohippus*, the Camelidae by Pliauchenia, the Dicotylidæ by several pieces of *Platygonus*, the Carnivora by an *Amphicyon* and other doubtful species of Canidæ. The collateral lines of Camelidæ, so far as we know, died out, and the adaptive rediation of the true camels begins.

However, no generalizations can as yet be made from this scanty fauna; we are confronted with more gaps in our knowledge and more unsolved problems than in any other period. Among these, the direct ancestry of the South American cameloids (*Auchenia*) as well as of the true camels (*Camelus*) should be found. We also should find here the stages directly ancestral to the horse (*Equus*), be-

2 *A New Three-toed Horse.* Bull. Amer. Mus. Nat. Hist., vol. xix, 1903, pp. 465-476.

cause it now appears certain that Marsh's *Pliohippus* was an Upper Miocene and not a Pliocene animal, and was, moreover, apparently on a side line not leading directly into *Equus* (Gidley, Fig. 4). Thus not only is the Pliocene plains fauna sparsely known but the Pliocene forest fauna is wholly unknown.

THE PLEISTOCENE FAUNA.

Equivalent to (1) the Preglacial, Forest Beds of Norfolk (St. Prest. Durfort, Malbattu, Peyrolles), (2) Glacial, (Mid-Pleistocene, Lower Mid-Pleistocene), (3) Postglacial deposits of Northern Europe and Asia.

Here again American palæontology is far behind that of Europe as to knowledge of the chronological succession of deposits, and a vast amount of work remains to be done in the discrimination of geological and faunal stages, in the comparison of Eastern and Western cave—and sand— deposits, and in the coordination of the first appearance of man with that of the mammalian succession.

The advent of the true *Equus* marks the base of our Pleistocene, as shown in the sand deposits of the Western plains in the so-called *Equus* beds. The geographical distribution and remarkable adaptive variation of the Pleistocene horses have now been fully worked out (Gidley[3]), proving that there are ten species characteristic of different localities, and ranging in size from *E. giganteus* larger than any modern horse, to the diminutive *E. montezumae*. But nowhere in North America have horses been found contemporaneous with man.

Two chief advances have been made, first, the distinction of plains and river, from forest faunas; second, the exploration of two very remarkable cave deposits.

The Western plains fauna of the *Equus* beds or Lower Pleistocene (Matthew[1]) contains among the Carnivora, *Canis*, *Dinocyon*, *Felis;* among the Rodentia, *Fiber*, *Arvicola*, *Cynomys*, *Thomomys*, *Castoroides;* among the Edentata, *Mylodon;* among the Perissodactyla, three species of

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3 *Tooth Characters and Revision of the Genus Equus.* Bull. Amer. Mus. Nat. Hist., vol. iv, 1901, pp. 91-142.
1 *List of Pleistocene Fauna from Hay Springs,* Nebr. Bull. Amer. Mus. Nat. Hist., vol. xvi, 1902, pp. 317-322.

Equus; among the Artiodactyla, two species of the Dicotylidæ; one species of the Camelidæ, and two of the Antilocapridæ (*Capromeryx*, a new form, Matthew), and *Antilocapra;* among the Proboscidea, *Elephas columbi* A similar plains fauna is that of Silver Lake, Oregon, which includes also two aquatic animals, *Castor* and *Lutra*. At Washtuckna Lake, Washington, is found a forest fauna which includes in addition to camels and horses, a badger, *Taxidea* three species of *Felis*, two of *Alces*, one of the American deer, *Cariacus*, and one of the goat *Oreamnos* (*Haploceros*)

Our knowledge of the Western cave fauna has been enriched especially by the discoveries of Sinclair[2] in California, in the Potter Creek Cave, probably of late Pleistocene age. This includes an extremely rich series chiefly of the mountain and forest type. Of fifty-two species, twenty-one are extinct, including a new member of the Ovinæ in the genus *Euceratherium*[3] (Sinclair). With these animals are associated relics possibly of human origin. In the East, the Port Kennedy Cave, also treated by Cope, has been exhaustively investigated by Mercer[4], and shown to contain fifty species of mammals, including chiefly forest types, among which are the *Mastodon americanus*, a tapir, and two species of *Equus*. Again no human remains have been found.

As regards phylogeny, the horses are evidently polyphyletic; but we have not as yet worked out the distinction between possible representatives of the horses, asses, and zebras. The Proboscidea have been clearly distinguished (Pohlig, Lucas, Osborn[5]) into four great types *Mastodon amercianus* in the Eastern and Middle States; *Elephas primigenius* in the North, practically identical with the north Asiatic Mammoth; *Elephas columbi* chiefly in the Middle States but also in the Southern, and *Elephas imperator* in the South and ranging north to the Middle States; these species represent profoundly different types both in skull

2 *The Exploration of the Potter Creek Cave*. Univ. Calif. Publ. Amer. Archaeol. & Ethn., vol. 2, No. 1, 1904.
3 *Euceratherium*. Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, No. 20, 1904, pp. 411-418.
4 *The Bone Cave at Port Kennedy*. Jour. Acad. Nat. Sci. Phila., vol. xi, pt. 2, 1899.
5 *Evolution of the Proboscidea in North American*. Science, N. S., xvii, Feb. 13. 1903, p. 249.

and tooth structure. *Elephas columbi* is analogous to the *Elephas antiquus* type of Europe; the *Elephas imperator* is rather analogous to the *E. meridionalis* of Europe. It is altogether probable that these species evolved in Eurasia and arrived fully formed in America. Naturally their geographical ranges overlap; but *E imperator* is never found in the extreme North, nor *E. primigenius* in the extreme South.

In conclusion, the great problem of all is the time of arrival of man amidst the Pleistocene fauna. This event is of such paramount importance that we must prepare for it by definitely determining the chronological stages of lower mammalian succession. At present man appears to be a late arrival, but personally I have a strong presentiment that human remains will be found in an earlier Pleistocene stage than is generally supposed.

CHIEF CENTRES OF ADAPTIVE RADIATION OF THE ORDERS OF MAMMALS.

I.—Jurassic Radiation (Partly Hypothetical).

Monotremata (Hypothetical, i. e. fossil forms not yet recognized.)

Marsupialia (Triconodonta).

Placentalia (Insectivora Primitiva, = Trituberculata.)

II.—Marsupial radiation, upper Cretaceous and Tertiary.

Australia (chief centre), Antarctica and South America. Only one family (Didelphyidae) certainly known in North America and Eurasia.

III.—First or lower placental radiation, upper Cretaceous and lower Tertiary (= Meseutheria Osborn.)

North America (chief centre), Europe, Africa (Creodonta), probably extending also to South America.

a. Orders Certainly Recognized.

Creodonta, surviving to Lower Oligocene.

Tillodontia, Middle Eocene (possibly related to Rodentia).

Taeniodonta, probably related to Edentata Gravigrada.

Condylarthra, surviving to Middle Eocene.

Amblypŏda, surviving to Upper Eocene.

b. Orders not certainly known in Basal Eocene but probably belonging to this radiation.

Insectivora, giving rise to modern Insectivora.
Lemuroidea.
Rodentia, Not yet certainly known earlier than Middle Eocene.

IV.—Second or Higher placental radiation (= Ceneutheria Osborn), Middle Eocene and Tertiary.

A. Chief centres North America and Eurasia, migrating to Africa and South America.

a. Orders derived from first placental radiation.

Edentata from Radiation III (North America only).
Insectivora from Radiation I and III.
Rodentia.

b. Orders characteristic of second placental radiation.

Cheiroptera.
Carnivora (Fissipedia and Pinnipedia).
Primates, Anthropoidea, possibly from Radiation III.
Perissodactyla, Lower Eocene.
Artiodactyla, Middle Eocene.

c. Centres of origin unknown.

Nomarthra or Effodientia (Lower Oligocene of France, *Necromanis* Filhol.)
Tubulidentata (First appearing in Lower Oligocene of France, *Palæorycteropus* Filhol).

B. Chief centre Africa, migrating in upper Oligocene (Sirenia), lower Miocene (Proboscidea), and Pliocene (Hyracoidea) to Europe, to Asia (Hyracoidea). Also to North and South America (Proboscidea).

Sirenia, Middle and Upper Eocene.
Proboscidea, Middle Eocene.

Hyracoidea, Upper Eocene.
Arsinoitherium.
Barytherium.

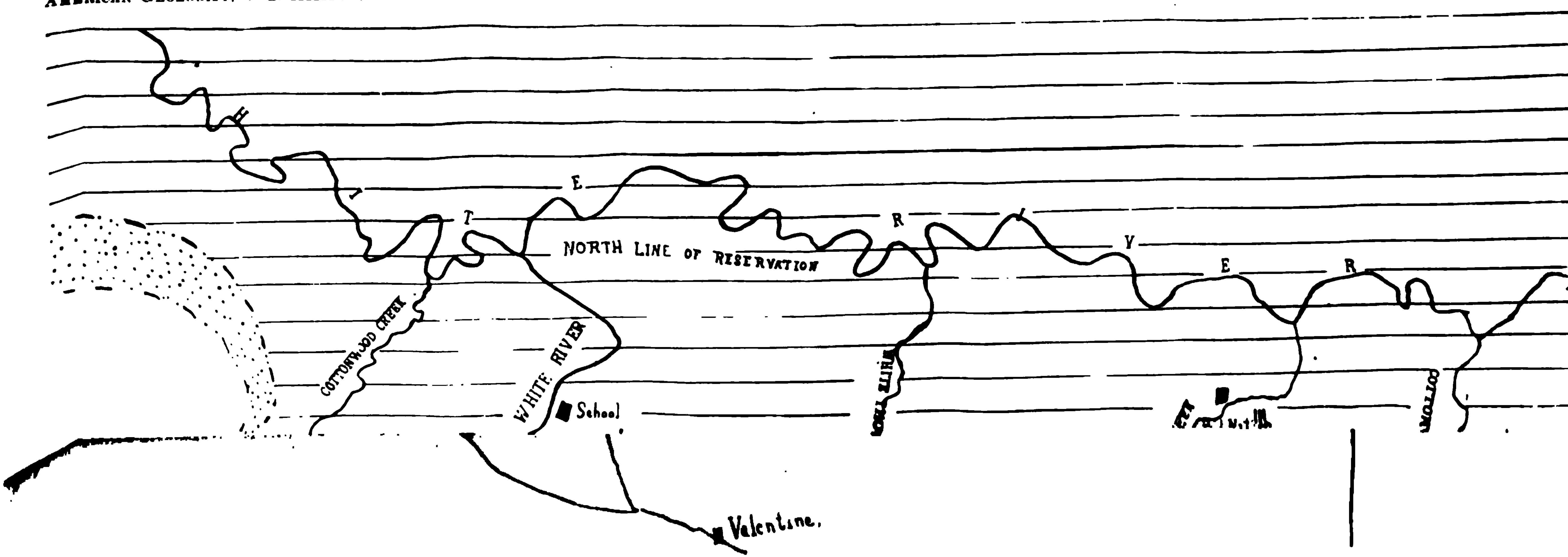
C. Chief centre South America.

a. Autocthonous orders.

Litopterna.
Toxodontia.
Typotheria.
Astrapotheria.
Pyrotheria.

b. Autocthonous or derived orders, in part.

Edentata, Suborders: Lorigata (Glyptodontia and Dasypoda), Pilosa (Gravigrada, Tardigrada, Vermilingua).


NORTH LINE OF RESERVATION
WHITE RIVER
COTTONWOOD CREEK
School
Valentine.
WHITE
COTTON

Thus the degree of zoological kinship of the continents may be expressed as follows:

1. Close kinship of North America, Asia and Europe (= Holarctica), having all pre-Miocene Orders in common, and separated only by the independent radiation of certain families.
2. Separation of Africa as a pre-Miocene centre of at least three orders not found in Holarctica.
3. Strong separation of South America from the Eocene until the Pliocene. Affiliation with Australia.

SOME GEOLOGICAL OBSERVATIONS ON THE CENTRAL PART OF THE ROSEBUD INDIAN RESERVATION, SOUTH DAKOTA.

By Albert B. Reagan, Mora, Wash.

PLATE XII.

CONTENTS.

The region under consideration extends from Valentine, Nebraska, north to beyond White river, the northern boundary of the Rosebud Indian reservation; and both to the east and to the west of the White Thunder day school of that reservation a distance of about twenty-five miles. It is wholly within the "high plains" region, and is a grazing country without trees of any sort except along its streams. Geologically the following formations are exposed: the

Recent and Glacial; the Ogallala, Arikaree, and Oligocene Tertiaries; and the Pierre shales of the upper Cretaceous.

SECTIONS.

1. Section on the bluff east of Little Oak Creek, one mile east of the Ring Thunder day School.

		Feet	Inches
	Oligocene:		
1.	Yellow thin-bedded, somewhat porous limestone....	40	
	Pierre Shales:		
2.	Black shale streaked with yellow bands of iron ore..	10	
3.	Black shale, carrying concretions of iron in which are occasional Baculite fragments...............	40	

2. Section in the Bad Lands four miles due east of the Little White river issue house.

		Feet	Inches
	Arikaree:		
1.	Sand	15	
	Oligocene:		
2.	Light colored shale	90	
3.	White, concretionary stratum.....................		4
4.	Light colored shale having an olive cast when wet..	5	4
5.	Hard white limestone stratum.....................		6
6.	Brown colored shale	4	
7.	Light gray shale, weathering brown...............	10	
8.	Cream colored shale	10	
9.	Jointed, very hard, yellow shale..................	18	

3. Section in a well at Butter Creek.

	Recent:		
1.	Yellow clay (bones of the buffalo and deer).......	10	
	Pierre Shales:		
2.	Black to gray shale..............................	12	

4. Section on west side of Oak Creek, eight miles south of Bad Nation school house.

	Glacial?:		
1.	Light colored clay..............................	10	
2.	Gravel		6
3.	Light colored clay		6
4.	Dark clay	1	
5.	Cobblestone-gravel stratum......................	3	
	Pierre Shales:		
6.	Grayish-black shales	120	

5. Section in the valley south of Little White River, one mile above the mouth of Cut Meat creek

		Feet	Inches
	Recent:		
1.	Light colored, finely laminated clay	2	
2.	Dark forest ground		8
3.	Yellow sandy clay	1	
4.	Fine to coarse, banded, cross-bedded, white sand	10	

6. *Section at the water's edge, south side of Little White river, one and one-fourth mile north of Ring Thunder school house.*

		Feet	Inches
	Recent:		
1.	Black earth	1	
2.	Gravel, light colored sands and clays, resting unconformably on the next	20	
3.	Partly lithified, light colored clay	10	
4.	Bedded gravel interbedded with bands of light colored sand. This stratum rests unconformably on the next following	12	
5.	Brown, clayey material, unconformable both with the stratum above it and the one below it	3	
6.	Grayish black shales	10+	

7. *Section one mile northwest of the White Thunder day school.*

	Oligocene (near base of the formation):	Feet	Inches
1.	Clayey shale in which are interstratified bands, three to five inches in thickness, of the same material containing some iron ore. The bands are harder than the other shales and show an iron-rust, red ochre color when wet	7	

8. *Section on Butte one mile southeast of the White Thunder day school.*

	Arikaree:	Feet	Inches
1.	Greenish, shaly to thin bedded very porous sandstone	6	
2.	Bluish to greenish, somewhat porous sandstone		10
3.	Greenish sandy shale	15	
4.	Clayey, thin-bedded, cream colored sandstone		14
	Oligocene:		
5.	Yellowish chocolate, cream colored, and pinkish shales	70	
6.	Greenish shales to thin-bedded, often porous, sandstone	4	
7.	Cream colored shales	4	

9. *Section two and one-half miles south of the White Thunder day school.*

	Arikaree:	Feet	Inches
1.	White to gray flint, in which are numerous gastro-		

	pod shells. This flint is the cap rock of many of the Arikaree buttes of the region adjoining the Oligocene outcrop	4
2.	Clayey, reddish brown sandy shale to massive sandstone breaking down in terraces in some places	25
3.	Unseen	60

10. Section on Rattle Snake butte, four miles south of the Butte Creek school house.

		Feet	Inches
	Arikaree:		
1.	Very hard, massive to thin-bedded sandstone, so firmly cemented with silica that the rock is a quartzyte. (The dip of these sandstone strata is toward the north	8	
2.	Volcanic ash	10	
3.	Hard, light brown, massive to thin-bedded, often laminated, cross-bedded sandstone (dip southeast)	140	
	Oligocene(?):		
4.	Unseen	100	
	Pierre Shales:		
5.	Unseen	40	

11. Section in the Bad Lands just across the river from the Ring Thunder day school Dip of strata north.

		Feet	Inches
	Arikaree.		
1.	Sand and sandy clay	40	
	Oligocene:		
2.	Light colored shale, weathering reddish on exposed surfaces, the reddish color being due to the particles of iron scattered through it	40	
3.	Light colored, occasionally greenish tinged, soft shales, banded with harder streaks of practically the same material, in which are occasional iron nodules. On weathering the whole series breaks down into light chocolate to pinkish and cream colored potato hills and cones, when isolated; and when joining a mesa, into smooth, symmetrical hogbacks	50	
4.	Same as three above except the shales have not the pinkish, greenish tinge in their color...........	45	
5.	Yellow, clayey shales, containing so many iron nodules that, at a distance, the exposure has a brownish to a red rust, red ochre color, due to the broken pieces of iron scattered over its face	10	
6.	Unseen	10	
	Pierre Shales.		
7.	Grayish-black shales (Baculites)	10	

Total thickness of Oligocene here	155	
Total thickness of section	215	

12. Section from the mouth of White Thnnder creek to the top of Mastodon buttes (Three Points) at the head of Oak creek, one mile east of the artesian well.

	Feet	Inches
Arikaree:		
1. Very hard, calcereous-cemented sand rock, in which are sticks, bones of birds, fishes, and animals, and fragments of turtle shell, cork-screw fossils, masses of fibers and rootlets, etc. This stratum is massive, and is the topmost rock of a great part of the Arikaree formation of the region. It is the Daimonelix beds of the Nebraska geologists, so named on account of the fossil cork-screws (Daimonelix) found in it	8	
2. Partly lithified sand, having the appearance of dune origin (camel, horse, birds, turtles)	10	
3. Partly lithified sand of stream origin. The water sorting, laminating, and cross-bedding are all in evidence. (mastodon, horse, camel, etc.)*	8	
4. Partly lithified sand	40	
Oligocene:		
5. Light colored to pinkish shales (estimated)	234	
Pierre Shales:		
6. Dark gray shales (estimated)	400	
Total	700	

13 Section from the bridge northeast of Rosebud to the top of the hill in the cut on the Rosebud Boarding school wagon-road. Altitude estimated.

Ogallala(?):		
1. "Mortar beds" of grit and calcarceous magnesian limestone permiscuously mixed	20	
Arikaree:		
2. Partly lithified ash gray to brown sand	60	
3. Buff colored sand forming a perpendicular bank on the Rosebud side of the stream	60	
Total	140	

Formations in Detail

The *Pierre Shales* of the Cretaceous system underlie the Tertiary formations wherever found and are the country rock in all places where the Tertiary has been removed by

* The writer sent the University of Indiana twenty-nine boxes of fossils from this locality.

erosion. As is shown by the map they cover all the lower country of the region and extend across the area at the head of Oak creek to the Kaya Paha (this latter was not positively determined to be Cretaceous). The formation is composed, principally, of dark gray shales containing brachiopod shells and Baculites. A bluff of this formation on the south side of White river near the mouth of White Thunder creek is three hundred feet in hight; Baculites were obtained from its summit. The entire thickness of these shales is not exposed in the region examined, although their thickness there must exceed 600 feet.

The shales are destitute of value, for they contain no stone, no building material, no water. The area they dominate is an alkali, salt grass, prairie-dog town country.

The *Oligocene formation* forms the clay bad lands lying between the Cretaceous and the Loup Fork (Arikaree and Ogallala) formations, forming a rough broken strip which runs in a general east and west direction across the country. It once covered the whole region as is shown by detached patches beyond the confines of the area mapped, but has subsequently been removed. Its strata are usually horizontal. They are composed, for the most part, of light colored to pinkish soft shales with which are interstratified bands of harder material carrying some iron. Sandstone strata, however, are occasionally exposed. The formation beginning with a cobble-stone gravelly stratum, lies unconformably on the Pierre shales. Its shales break down and so slack in water that they are readily carried off with it. When mixed with sand in the right proportion, the clays formed from the shales make a hard cement, which the Indians use in plastering. The cream colored to pinkish colored potato hills, cones, castles, terraces, and hog-backs, formed by the breaking down of these shales, make this strip picturesque.

The formation has the appearance of having been begun by river action. Later, judging from the fineness of the material, the area must have become a deep lake and remained such for a long period. Finally, the lake was filled with sediment till the region reached the swamp stage; the deposition then ceased.

The *Arikaree Formation* overlies and rests unconformably on the Oligocene series. It covers the entire southern half of the area mapped, save where it is removed by erosion at the head of Oak creek. Farther to the north several detached patches also occur. It probably once covered the whole region, but must have been very thin along the northern border, as the exposures show that it gradually thinned toward the north. At Valentine, Nebraska, it is over 400 feet in thickness, while at the artesian well it is less than 160 feet. It is composed mostly of sand in various stages of hardness, ranging from the very hardest, unmetamorphosed rock in the Rattle Snake buttes to wholly unlithified sand in many other places. The latter, however, is packed so hard by pressure that a pick can hardly be driven into it. At all places where the whole series is exposed, it is found to be capped with a very hard calcium cemented sand rock from eight to twenty feet in thickness, except in the Rattlesnake Butte region where it is quartzyte sandstone. On the whole it seems to be dry delta, dune, and river-channel formation instead of lake deposit, as was formerly believed. The whole region seems to have reached the ponded stage at the close of the epoch. The strata thicken and thin alternately. They are often fan shaped. Many that are very thick pinch out in a short distance. Many show water sorting; some only for a little ways, others throughout the entire exposure. Others are composed wholly of fine dune sand; while others are heterogeneously mixed. Many show cross-bedding. In some places the strata pitch at a high angle one way for a little distance and at another angle a little farther on, notwithstanding that the Oligocene immediately underlying them is horizontal. In many other cases the strata dip in all directions from a common center, the formation indicating that it is likely an alluvial fan deposit.

So far as the writer could determine, there is no evidence that the formation is lake deposit. On the contrary, land snails, bones of the horse, camel, mastodon, and other land animals, together with the dune material, seem to indicate that it is stream, pond and æolian in origin.

From the observations of the writer, which were not

extensive enough to form any definite conclusion, it would seem that possibly a large stream flowed to the Gulf along the line of the sand deposits, the deposits being the debris left by its ever changing channel. A re-elevation of the central plain, after a long lapse of time, diverted the drainage and left the region, first, a ponded area as is shown by the pond-holes, and, then, arid land.

Again, the origin of the deposits might be explained by another hypothesis as follows: That after the re-elevation of the Rocky mountains just before or at the beginning of the Loup Fork epoch, the streams, flowing east from the continental divide, had not, as yet, formed permanent channels across what is now our western plains. Consequently, after flowing rapidly down the mountain slopes, they spread out on reaching the slack-water region of the plains forming dry deltas or alluvial-fan deposits. This they continued to do till time and re-elevation of the plains region caused them to cut permanent channels to the Mississippi river and the gulf of Mexico.

The *Ogallala (?) formation* was found exposed in a cut on the Rosebud-Boarding School wagon road one-half mile northeast of Rosebud. In general appearance and in composition it resembles the "mortar beds" of Kansas very much. It is essentially a limestone of the calcareous magnesian type containing many impurities. The limestone is wavy, looks much as if it had been run through a crimping machine before hardening, is somewhat continuous in stratum form, and, besides being gritty itself, is intermixed with grit and sand.

In this formation the writer found bones of the mastodon, horse and camel, fragments of turtle shell, and the bones of birds.

In places the limestone of these beds is used for building purposes, for which it is said to be a good rock.

On the map (plate XII.) these beds and the underlying Arikaree are mapped together as Loup Fork Tertiary.

Glacial (?) debris, rock, which seemed to be of glacial origin, was noticed at several places on the bluffs of lower Oak creek. As the great glacier extended to the Missouri adjacent, it is highly probable that a glacial lobe crossed

over to the White river—Oak creek side. It will necessitate more research work, however, to determine this fact.

The *Recent formation* (not mapped)extends out on the bluffs on either side of White river for quite a little distance. It is the surface rock in all the valleys wherever the valley widens out. Along White river and Little Oak creek it covers the meander region. The bluff formation is probably Champlain in age, some being probably even Glacial. The formation in the valleys is more recent and extends in time to the present. Little Oak creek is now building up its lower valley; and White Thunder creek its valley in its middle course. The whole formation, whether in the valley or on the bluffs, is of river origin.

To this age of rocks seems to belong the Tertiary debris from the broken down mesas and bad lands. Though patchy, this debris covers at varying thicknesses a considerable part of the area marked Cretaceous; the Tertiary, however, is not in "situ" nor in thickness enough to determine the surface age.

Resume: As the Cretaceous period neared its close the surface of the region became dry land and was such for a long period as is shown by the then eroded surface. The region then, in Oligocene times, began to fill with debris of the gravelly cobblestone type. Later it apparently became laked, and the soft fine-grained shales were deposited. While this was going on, fresh-water fish and gigantic turtles skimmed the waves and tropical animals roamed along the beach. After a long lapse of time, the region again became land and was much eroded. Another period of deposition then, in Loup Fork times, set in. The whole area was flooded with sand. This was deposited at intervals till it reached a thickness of more than 400 feet in the vicinity of Valentine, Nebraska. Throughout the whole time the region seems to have been in a swamp or ponded state. As the climate was tropical, there roamed over the marshy areas and through the jungles the tiger, horse, hyena, camel, mastodon, and the many other tropical animals of that epoch, as is shown by their fossil remains. The region was left ponded at the close of this epoch. In the succeeding epoch the present streams cut their channels to about their

present depth. In the Champlain epoch they refilled them or were so filled with water that they deposited debris far out on the adjoining mesa lands. Since then stream action and deposition have been going on about as now.

Bad Lands.

The bad lands are along the Oligocene outcrops. They are typical "mauvaises terres," but of course are less extensive than those farther west. They are almost destitute of vegetation; and are chiefly noted for their picturesqueness and for their being the home of the gray wolf and the coyote.

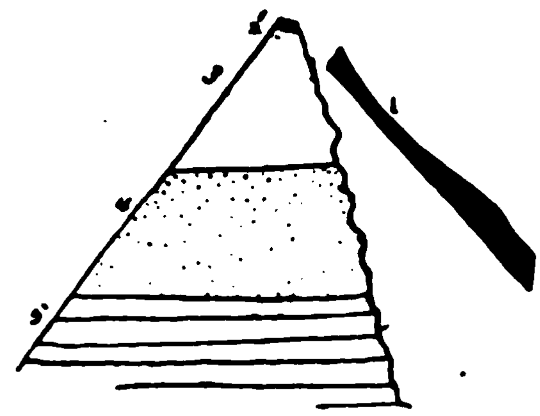
Buttes.

The buttes are situated upon the Oligocene along the break line of the Loup Fork, the strip having a general east and west trend. The buttes are conical or rectangular and flat topped, depending upon the hardness of the cap rock; the latter usually have their longest axis parallel with the nearest stream. The rectangular buttes in the vicinity of the White Thunder day school and those in the Robinson bad lands are capped with flint. The Rattlesnake buttes are capped with quartzyte sandstone. The conical buttes are generally capped with the Daimonelix beds of the Arikaree formation where they have not been removed by erosion. The buttes occupy the inter-stream spaces and range from 200 to 300 feet in hight.

It would seem from the observations that the flint and quartzyte capped buttes represent ponded areas of Arikaree times; the Daimonelix beds, sand dune and stream regions, the flint and quartzyte sandstone having been formed under water. This opinion is strengthened by the fact that the flint contains snail and turtle shells; the Daimonelix beds and sand areas, the bones of land animals. This difference in the formation of the original surface has been a leading factor in determining the course and position of the streams. The inter-ponded spaces, though being the higher ground, were less hard and have yielded more readily to erosive action; hence are now the valleys.

Rattlesnake Butte.

The Rattlesnake buttes were so named on account of



An east and west section through Rattlesnake Butte, showing the displaced rock to the north. Explanation: 1, quartzyte sandstone; 2, volcanic ash; 3, sandstone; 4, Oligocene shales; 5, Pierre shales. 1-3 are Loup Fork Tertiary. Altitude 300 feet.

the great number of rattlesnakes found there. At any time in summer the "rattlers" can be seen basking in the sun by the hundred. The cap rock of these buttes, as we have seen, is quartzyte sandstone. On the longest and highest butte, called Rattlesnake butte, it is very thick, and the strata are usually massive. This butte has had a geological accident in the recent past. It has been split in two along its longer axis, and its northern half has slid down the slope to the north, so that what was once the top is now the north face of the bluff, the rock dipping north 45 degrees. Thus tilted, the broken edge forms a ridge parallel to the remaining original top, a narrow valley occupying the intervening space.

Another geological accident awaits this butte in the near future of geologic time. It will then loose its top. This top is very narrow, ten to twenty feet wide and already has a dip of ten degrees toward the north, while the strata immediately underneath dip south.

Minerals.

So far as the writer knows there are no minerals in the region worth mentioning, he not having paid any attention to minerals in his investigations. He believes, however, that the Miocene (Oligocene) shales which the Indians use in plastering might prove of value in the making of cement. Besides this possibility of the clays (shales) being of value, placer gold is said to exist in the gravels at the mouth of Oak creek.*

* Some volcanic ash was noticed at several places, but the quality and quantity were not determined.

Soil.

The soil on the Oligocene formation and on a great part of the Cretaceous is very poor; but in the valleys and in the Loup Fork districts it is good, producing excellent crops whenever there is a sufficient amount of rainfall.

Water.

The water of the Cretaceous country is bitter to the taste and usually contains alkali, sometimes in such quantities that it kills stock or "alkalies" them, that is, causes them to loose their hoofs. The water of the sand districts has a good taste and is usually wholesome. Here the water for ordinary drinking purposes is furnished by comparatively shallow wells.

Throughout the entire region mapped if the water is running slow or is in a standing condition, it has a color similar to that of the water in a drain from a barnyard.

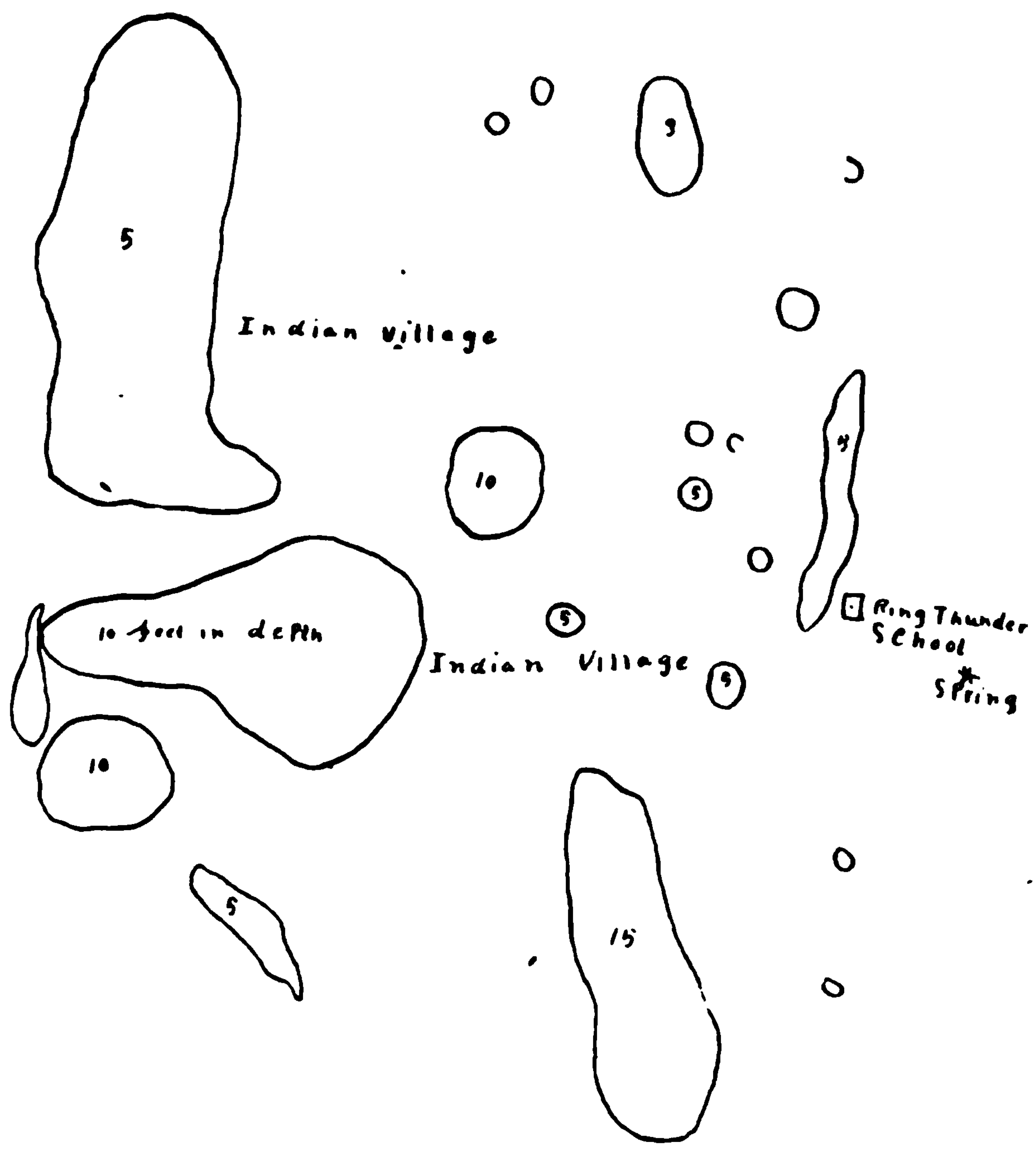
Sink Holes, Ponds and Lakes.

Dry sink-holes, ponds, and lakes of considerable size are scattered over the entire country. The sink-holes are due to underground drainage. In many places the last twenty to forty feet of the Oligocene, except the very last stratum, is often a very porous limestone; the same is also true of the lower strata of the Arikaree formation, except that the porous rock is sandstone. Consequently sink-holes are readily formed when the less porous rock is removed. In these holes after a big rain the water quickly seeps away and comes out below in springs. The ponds and lakes remain partly filled with water most of the year, though their dimensions are small compared with what they were formerly as is indicated by the old beach lines, especially in the case of the larger lakes. Some of the lakes have water in them throughout the year. The ponds and lakes are usually due to the unequal piling of the surface debris of the formation in which they occur. The most of them are on the Loup Fork formation.

Springs.

Most of the springs are located at the heads of the several streams along the contact lines between the Loup Fork and the Oligocene and the Oligocene and the Cretaceous. The springs of the former group are good drinking water,

those of the latter very poor. The latter have a soapy, clayey taste. The springs at the Ring Thunder day school besides having this taste is contaminated with the drainage from the Indian village above as is shown in the accompanying map of the sink-holes there. The Loup Fork springs in the vicinity of Valentine and Fort Niobrara and in Smith's canyon ten miles farther east are large. Those at Fort Niobrara furnish water for the fort, and the Smith canyon springs water over two thousand head of cattle. None of the springs possess medicinal properties.



North sink holes in the vicinity of the Ring Thunder School.
Scale ——— 300 feet.

Streams.

The streams are White river and its tributaries at the north, and the Kaya Paha and the Minichadusa at the south. All of the head streams of the Kaya Paha run above the Oligocene. Antelope creek is always clear and always has running water in it. The tributaries of the White

river all head at the top of the divide in the Loup Fork formation. They have water in their upper courses; but, as these streams are building up their middle courses with Loup Fork sand, the water, on reaching this part of its respective channel, sinks beneath the surface. White river itself is a large stream and is scarcely fordable on account of its quicksand. In many places its banks are very steep forming canyon walls. The water of the stream in the rainy season is white, the color being due to the white Oligocene sediment carried in the water from the Bad Lands. At other seasons of the year the water is practically clear.

Why the southern tributaries of White river are building up their channels in their middle course The streams flowing north from the vicinity of the artesian well cut through both the Loup Fork and the Oligocene formations in the first six or eight miles of their respective courses, falling in that distance from three hundred to three hundred and fifty feet. Then as the Cretaceous shales yield less readily to the erosive efforts, the fall is not maintained from there on. Hence a slack-water region is produced. In this the Loup Fork sands are deposited, except in high flood times when force enough is given to the water by its volume to carry the sediment with it to the master stream. The aridness of the region aids in building up this middle course.

Change of Drainage Courses. In the early history of Antelope creek it seems to have flowed north as the head stream of Little Oak creek, as its direction of flow would tend to take it to-day. Finally the Kaya Paha tapped it above the site of the boarding school and captured its upper tributaries, leaving Little Oak, its lower channel, to dwindle to a dry stream. The wind-gap through which the original stream seems to have run together with the great bend on Antelope creek at this point bears out this conclusion.

Antelope creek is now in danger of itself being tapped in the near future of geologic time by White Thunder creek. This creek runs, as it were, at right angles to the Antelope; that is, it would form a pretty good perpendicular to the Antelope if continued to it. The Antelope is at least

one hundred feet higher than White Thunder creek four miles away; and both streams, here, have their channels in the Loup Fork sands. It seems to be only a question of how long it will take, the result is evident.

Oak creek is likely to make a similar capture of the Kaya Paha at some time.

Why White river has all its tributaries on its southern side. The Cretaceous north of White river dips north and naturally causes the watershed of that stream on the north to be the bluffs on that side. In addition to this, the greater part of the strata to the north are Cretaceous shales, while to the south they are horizontal, softer, Oligocene shales and Loup Fork sands. The Tertiary being the easier eroded the river has cut its tributaries on that side.

Irrigation.

Irrigation is not carried on at all on the reservation; but could be in the valleys of White river and its larger tributary, Little White, also along Antelope creek, with but little expense. The valley of Little White is about a mile wide in its lower course; and, as the stream is at base level there and at the level of the valley floor, this whole valley could be made a garden. It would necessitate considerable fluming, however, to irrigate the bottom lands of Big White, as the master stream is usually called on the reservation, for the bluffs wedge in to the water's edge occasionally; but in the end it would pay. The land is of good quality and would be very productive if water could be got to it.

The Kaya Paha and its head stream, Antelope creek, have plenty of water and also flat valleys. It seems a shame that the Indians allow so much water to run to waste each year, when, if properly used, the government would not be compelled to feed and clothe them.

The creeks that are tributary to White river would furnish no water for irrigating purposes, not even by the storage reservoir system. Except in flood times, they are practically dry; and water stored in them seeps away in the sand that fills their channels. Side reservoirs in the little ravines having Oligocene or Cretaceous shales for a bottom are the only reservoirs that hold water for stock during the dry season.

NOTES ON THE DISTRIBUTION OF BRACHIOPODA IN THE ARNHEIM AND WAYNESVILLE BEDS.

By Aug. F. Foerste, Dayton, Ohio.

In the first volume of the Geology of Ohio, published in 1873, on page 397, Prof. Orton states that the lowest horizon at which *Leptaena rhomboidalis* (*Strophomena tenuistriata*) is found is at the very summit of the Cincinnati hills, or about 455 feet above low water. The geological horizon at which the *Leptaena* occurs at Cincinnati is fixed by the statement, on page 394, that at a hight of 425 feet above low water a belt of rock, two to ten feet in thickness, occurs which is almost entirely composed of the ventricose full-grown shells of *Platystrophia lynx* (*Orthis biforata*.) This Lynx horizon was considered as forming virtually the summit of the Cincinnati section, notwithstanding the occurrence of *Leptaena rhomboidalis* at a higher horizon. The reason is given on page 370, where it is stated that the greatest elevation above low water in the immediate vicinity of Cincinnati is given by the city engineer as 465 feet. Subtracting 15 feet for the drift covering at the surface we can certainly find 450 feet of bedded rock at Cincinnati, almost every foot of which lies open to study within the city limits. The only stratum, however, that admits of easy identification, lies at an elevation of 425 feet above the river, and this accordingly is assumed as the upper limit of the division to which Prof. Orton gave the name Cincinnati beds proper.

The *Platystrophia lynx* horizon at Cincinnati forms the Mount Auburn bed of Nickles (The Geology of Cincinnati, Journal, Cincinnati Soc. Nat. Hist, 1903). If its thickness be estimated at 20 feet, it is evident that the specimens of *Leptaena* must have occurred at least 10 feet above the base of the Arnheim or Warren bed. This estimate is probably too low, but the former presence of the lower part of the Arnheim bed at Cincinnati is certain.

Laptaena rhomboidalis is widely distributed in the Arnheim bed. In Ohio and Indiana it occurs near the middle of the bed, making its first appearance a short distance below the *Dinorthis retrorsa* horizon and continuing to a little above this horizon. It occurs at this horizon along Reser-

voir creek, north of Lebanon, Ohio; also seven miles northeast of Lebanon, on Lick run, opposite the mouth of Caesar creek; along Short creek, below Arnheim, 42 miles southeast of Lebanon; about three miles south of Maysville, Kentucky, along the railroad, and 22 miles south of Arnheim. In Indiana, *Leptaena rhomboidalis* occurs at the *Dinorthis retrorsa* horizon about 40 miles west of Lebanon, and five miles east of Brookville, on Big Cedar creek, a short distance south of the pike to Mount Carmel; also 23 miles south of Brookville, about a mile southeast of Sparta, east of the Sparta fork of Allen branch; 33 miles southwest of Sparta, opposite Madison, along the pike from Milton, Kentucky, to Bedford, at the head of the first gully crossed by the pike, about on the same level as the bridge, about a mile south of the Ohio river; about 20 miles southeast of Madison, about a mile east of Pendleton, Kentucky, on the Louisville and Nashville railroad, at the second railroad cut east of a house on the north side of the railroad. The association of *Leptaena rhomboidalis* with *Dinorthis retrorsa* has not been noted, so far, at any locality south of those mentioned as occurring near Maysville and Pendleton, Kentucky, but this is merely because *Dinorthis retrorsa* has not been detected farther southward. *Leptaena rhomboidalsi* continues to occur at the same horizon at least as far as Lebanon, Kentucky. *Dinorthis retrorsa* is listed by Linney in his Notes on the Rocks from Central Kentucky, published by the Kentucky Geological Survey in 1882; but it is not stated at what locality it was found, although the list presumably includes only fossils from the counties lying between Madison and Marion county. In the Geology of Marion county, by W. T. Knott, and published in 1885, however, the name does not occur.

There is no very good reason for doubting the accuracy of the identification of *Dinorthis retrorsa* from central Kentucky. The fossil has a very characteristic form and should not readily be mistaken. At any rate, *Dinorthis retrorsa* has been found associated with *Leptaena rhomboidalis* as far south as the landing at Clifton, on the Tennessee river, in western Tennessee.

Another fossil having a considerable distribution at the

Dinorthis retrorsa and *Leptaena rhomboidalis* horizon is *Rhynchotrema dentata*, or, at any rate, a scarcely distinguishable variety of this species. It occurs at this horizon at Arnheim, Ohio, and near Maysville, Kentucky. Farther southward, in the absence of *Dinorthis retrorsa*, it may be traced along the same horizon, in association with *Leptaena rhomboidalis*.

Rynchotrema dentata occurs associated with *Leptaena rhomboidalis* at the Brown's run school house, about 8 miles southeast of Maysville, two miles northeast of Rectorville; also 30 miles south of Maysville, at the foot of the hill east of Wyoming; 14 miles southwest of Wyoming, about half a mile southwest of Howard mill, on the road over the hill to Spencer; 13 miles southwest of Howard mill, at the Curry bridge across Howard creek, reached by going a mile south, and then two miles west from Indian Fields. A mile north of the crossing of the Stanford-Rowland pike over Logan creek, at a large exposure on the western side of the creek, *Leptaena rhomboidalis* was found in the upper part of the exposure. *Rhynchotrema dentata* is found associated with *Leptaena rhomboidalis* also a mile and three-quarters west of the court house at Lebanon, Kentucky, near the lower part of a gully located 20 degrees west of north from the home of Col. J. B. Wathen; also 30 miles northwest of Lebanon, half a mile north of High Grove, and about six miles south of Mount Washington.

Leptaena rhomboidalis may be found at many localities at which *Dinorthis retrorsa* and *Rhynchotrema dentata* are absent. This horizon in the Arnheim bed is fairly fossiliferous at all localities in Ohio, Indiana, and Kentucky. On this account it may be traced with confidence entirely around the Ordovician area of Ohio, Indiana, and Kentucky. It promises to be a very valuable horizon for purposes of mapping, especially for those who are not familiar with the bryozoans of this area, the bryozoans, after all, constituting the final authority in the discrimination of Ordovician strata.

Rhynchotrema dentata is found in association with *Leptaena rhomboidalis* and *Dinorthis retrorsa* also at Clifton, Tennessee.

On the eastern side of the Cincinnati geanticline,

Platystrophia lynx is very abundant in the Mount Auburn bed, but along this area it is found also in the Warren bed, usually near the middle of the Arnheim bed, but a short distance beneath the *Dinorthis retrorsa* horizon. In the lower part of Lick run, opposite the mouth of Caesar creek, northeast of Lebanon, Ohio, *Platystrophia lynx* occurs 7 feet below the *Dinorthis retrorsa* horizon. Near Arnheim, Ohio, it occurs about 8 feet below *Dinorthis retrorsa*. At Wyoming, Kentucky, a massive, fine grained, argillaceous, blue limestone underlies the horizon containing *Rhynchotrema dentata* and *Leptaena rhomboidalis*, and at various levels in this rock *Platystrophia lynx* may be found. *Platystrophia lynx* is associated with *Leptaena rhomboidalis* at this horizon at all points farther southward. At some of these, for instance at the locality west of Lebanon, *Platystrophia lynx* occurs both above and below this horizon. On the western side of the Cincinnati geanticline, a few specimens of *Platystrophia lynx* may be found two or three feet above the *Leptaena rhomboidalis* horizon even as far north as the locality along the creek, about a mile south of Mount Washington, in Bullitt county, Kentucky, but farther north no specimens of *Platystrophia lynx* have been detected as yet in the Arnheim bed. As far as may be judged from the evidence at hand, *Platystrophia lynx* after a period of extraordinary development during the Mount Auburn period , was much reduced in numbers and disappeared northward, but continued to exist in southern Kentucky during the deposition of the lower part of the Arnheim bed. During the middle of the Arnheim period it increased in numbers and extended its range northward at least as far as Lick run on the eastern side of the Cincinnati geanticline, but on the western side it has not been found at this level, as yet, north of Mount Washington.

No specimens of *Platystrophia lynx* were found at the *Dinorthis retrorsa* horizon, at Clifton, Tennessee, but at Newsom, about 15 miles southwest of Nashville, a single good specimen was found in association with four specimens of *Rhynchotrema dentata* in what is regarded, provisionally, as equivalent to the Arnheim bed.

Another fossil, whose presence near the middle of the

Arnheim bed is of interest, is *Dalmanella jugosa.* This species occurs in such great numbers in the lower part of the Waynesville bed in most parts of Ohio and Indiana, that this part has been called the *Dalmanella zone.* However, it occurs at some localities also in considerable numbers in the middle and lower part of the Arnheim bed. This is true especially in Franklin county, Indiana. Its range begins at least 10 or 15 feet below the *Dinorthis retrorsa* zone, and extends for several feet above the latter. On the eastern side of the Cincinnati geanticline, at Arnheim, Ohio, *Dalmanella jugosa* is rather abundant in a layer, nine inches thick, also containing *Platystrophia lynx* which is nearly 9 feet below the *Dinorthis retrorsa* horizon. It occurs associated with *Platystrophia lynx*, also at Maysville, Kentucky, eight feet and three inches below the lowest specimens of *Leptaena rhomboidalis* and a greater distance below the *Dinorthis retrorsa* horizon. At most localities, however, *Dalmanella jugosa* rare, or even absent, in the Arnheim bed.

Dalmanella jugosa is found associated with *Dinorthis retrorsa*, *Rhynchotrema dentata*, and *Leptaena rhomboidalis* at Clifton, Tennessee, and is associated with *Platystrophia lynx*, and *Rhynchotrema dentata* at Newsom, in that state.

On going from Maysville, Kentucky, and Madison, Indiana, southward, toward central Kentucky, the lower part of the Richmond is found to become rapidly more argillaceous and less fossiliferous. At the more southern localities, in central Kentucky, there are no specimens of *Streptelasma*, *Protarea*, *Strophomena*, *Leptaena*, *Rhynchotrema capax*, no numerous specimens of *Dalmanella jugosa* present, as in the lower part of the Richmond in Ohio and most of Indiana. A thin zone of bryozoans, several feet thick, is found at the very base of the Richmond, but, for those who do not make a special study of bryozoans, their identification is not easy, and their utilization for determining the boundaries between the Richmond and Maysville or Lorraine divisions of the Cincinnatian becomes impracticable. Hence the great value of the *Dinorthis retrorsa*, *Leptaena rhomboidalis*, *Rhynchotrema dentata* horizon for the aver-

age investigator. With this horizon as a guide, the line between the Richmond and Maysville, determined at a few localities by an expert on bryozoans, may be followed for long distances merely by taking advantage of lithological differences.

Another point of interest in connection with this *Dinorthis retrorsa*, *Rhynchotrema dentata*, and *Leptaena rhomboidalis* zone at the middle of the Arnheim bed is their recurrence in the Waynesville bed. They are found in the upper third of the Waynesville bed in various parts of Union and Franklin counties, Indiana; and *Rhynchotrema dentata* and *Leptaena rhomboidalis*, without the presence of *Dinorthis retrorsa*, are widely distributed at this horizon in Ohio, Indiana, and adjacent Kentucky.

A most interesting case of the recurrence of species has recently been discovered by Dr. George M. Austin at Stony Hollow, north of Todd fork, at Clarksville, southwest of Wilmington, Ohio. Here *Herbertella insculpta* occurs in the Waynesville bed thirty feet below the chief *Herbertella insculpta* horizon which is used to distinguish the Waynesville bed from the Versailles or Middle Richmond bed. *Zygospira kentuckiensis* was found 15 feet below the top of the Waynesville bed, and about 45 feet above the base. East of Pendleton, Kentucky, *Zygospira kentuckiensis* occurs in association with *Tetradium fibratum* and *Calopoecia cribriformis*, 5 feet below the lowest layers containing *Streptelasma rusticum* and *Strophomena planumbona*, and between 40 and 50 feet above the base of the comparatively nonfossiliferous beds which here represent the middle and lower part of the Waynesville bed. The same *Zygospira kentuckiensis* horizon is exposed at the mouth of Bull Creek Clark county, Indiana. Here the lowest layers containing *Dinorthis subquadrata* occur 20 feet above the top of the *Zygospira kentuckiensis* horizon, with *Streptelasma rusticum* *Columnaria halli*, *Strophomena planumbona* and *Rhynchotrema capax* in the intervening rocks. This *Zygospira kentuckiensis* horizon, with the overlying fossiliferous beds may be traced as far southward as Lebanon, Kentucky. It was noticed by Linney in Nelson county, Kentucky (Geology of Nelson county, 1884, page 34). The *Rhynchotrema denta-*

ta and *Leptaena rhomboidalis* mentioned in the same sentence occur much lower, associated with *Platystrophia lynx*, in the Arnheim bed. East of Pendleton, in Henry county, the *Zygospira kentuckiensis* horizon is found 73 feet above the horizon containing *Dinorthis retrorsa* and *Leptacena rhomboidalis*.

EDITORIAL COMMENT.

THE WILLIAMETTE METEORITE.

Mention was made in the current volume of this journal (p. 47) of this wonderful meteorite. Later it was transferred to the "mining building" at the Lewis and Clark Exposition, at Portland, Ore., where it remained till the close of that exposition. As it was being moved into the building the writer made (August 23) the photograph which is reproduced herewith, (plate xiii, fig. 1). Prof. H. A. Ward has published a description of this iron,* with ample illustration, and the accompanying figure 2, of plate xvi, is taken from his publication.

The general shape of the mass is that of a depressed liberty bell somewhat elongated by lateral pressure. The general outline is rounded, there being no angularities except at the edges of the basins or holes that penetrate it, and which occupy a large part of the lower surface. The size of the mass is expressed by the following dimensions:

Extreme length 10 ft. 3½ inches.
Breadth 7 ft.
Hight 4 ft.
Estimated weight, from 12 to 15 tons.

When it was discovered it lay nearly buried in the earth and soil, but a small part of it being visible. On being exhumed it was found to lie with its conical point downward, the reverse of the position shown in fig. 2 of plate xvi. It is probable that in passing through the air in its descent it had that position. The denser part is in the cone and that

* Proc., Rochester Academy of Science, vol. 4, pp. 137-148, March, 1904.

FIG. 1. THE WILLAMETTE METEORITE.
Size: 10 ft. 3½ in. × 7 ft. × 4 ft.

FIG. 2. THE WILLAMETTE METEORITE
Showing the Concavities on the Lower Surface

part must necessarily have been in advance of the lighter portion, which was that shown now by the lower surface. The lower surface has lost a large portion of its original mass through the removal of such ingredients as once filled the openings. Those ingredients were certainly not metallic iron, but probably such stony matter as is frequently known to accompany sideritic meteorites; although at the present time no trace of such stony matter remains.

The whole surface has lost its original scale, if it had one, and is covered now by a film of iron rust, which, in some of the protected depressions at the base of the conical part, is so thick that it forms a firm scale about a thirty-second part of an inch in thickness. Such scale of iron rust, which must have covered the whole mass rather uniformly originally, and has been rubbed off by the accidents of transportation, indicates the long period of time which has elapsed since the iron reached the earth. It appears to require an oxidation continued through many centuries, and perhaps thousands of years. On the conical part Dr. Ward mentions the occurrence of isolated small protuberances of a slightly darker shade than the main mass. He attributes them to "flows of melted matter which were once more widespread, or continuous;" they would, in that case, be remnants of the fused dark film by which all meteorites are covered when they fall. It might be questioned, however, whether such fused flowage matter would be less or more oxidizable than the mass of the iron. Being non-crystalline it would be reasonable to expect it to be more attackable by the atmosphere, and by moisture in the ground, than the crystalline iron mass, and hence, rather than standing out in prominences it would wholly decay and slough off before the iron could be reached. The writer noticed these darker patches, which average from half to three-quarters of an inch across, and on the spot assumed that they are due to inequalities in the iron, or to the occurrence of some ingredient less oxidizable than the iron by which they are surrounded. They do not appear to be composed of troilite nor of any silicate, and the the occurrence of diamonds of that size, while possible, is perhaps too bold a suggestion to be entertained.

The flange, or rim, of the meteorite presents characters very remarkable and different from the conical part. Here can be seen those surface pittings which are common on meteorites. They are coarse, sometimes reaching more than an inch in diameter. They can be seen on the plate (xiii) at the lower left hand corner of figure 1 and less distinctly at the right hand lower corner and uniformly over the lower surface in figure 2. So far as the writer observed there is here no remnant of the "black crust," but the depressions are covered with a later-formed crust of iron rust. This rusting, however, appears to have been less intense than on the cone. The film is not so thick and the pittings themselves are not destroyed. This difference may be due to the fact that the upper surface, as it lay in the ground, was less continuously wet, and may have stood for many years some inches above the surface of the soil. These surface pittings do not appear in the basins and holes that characterize the lower surface of the meteorite, but the interior surfaces of those basins are marked by larger, irregular swellings and branches that resemble, in shape the irregularities which mark the outlines of these basins at their intersection with the general surface. This curious appearance is illustrated by fig. 2, plate xvi, where, by a conceit of the photographer, two children are seen resting in the concavities.

It is only by reference to the photograph copied from Dr. Ward's description, that one can get a correct idea of these most singular concavities. They swell out so as to come into union with each other, or almost into contact, separated only by thin partitions of the metallic iron of the mass. The iron which separates these basins along such partitions, leaves on breaking down, or rusting away, sharp edges and little buttresses. Some of the depressions are small, not more than an inch in diameter. They all come to sharp edges where they intersect the pitted surface, and almost without exception they are larger at some depth from the surface than at the surface. The smaller ones appear not only in the main metallic mass, near the base of the conical part, but most abundantly throughout the iron that encloses the large concavities. Some of these smaller openings [illegible] like auger holes, and some of them pass

quite through the flange, being a foot or more in length and only an inch or two in diameter. From these elongated holes there are all stages of gradation to the shallower and larger basins, indicating a common nature and origin.

Dr. Ward makes a distinction between the channels and basins on the two sides (the upper and the lower) of the iron mass. Those on the conical side (the brustseite) are attributed by him to atmospheric pressure and friction. Those which cross the outer edge of the great flange, cutting channels across its outline, he likewise ascribes to the action of the compressed air and the heat resulting from the passage of the mass through the atmosphere, while those which are wholly confined to the lower surface, not penetrating deep enough to reach the brustseite, nor extending laterally far enough to reach the outer edge of the flange, he attributes to atmospheric decomposition of the iron since it fell, aided by the moist soil and the carbonic acid resulting from vegetable decay.

The parties having the meteorite in charge at the Lewis and Clark Exposition, attached a label which read as follows, evidently derived from Dr. Ward's paper:

"When this meteorite was discovered it was imbedded in the earth, the base uppermost, the position which it probably held when it fell through our atmosphere, centuries ago. The pitting, hollowings, and channelings observed on the surface are due to the heat caused by the compression of the air."

We are compelled to take sharp issue with Dr. Ward as to the origin of these features. We did not notice any of those differences which he mentions, and most of the hypothetical operations of the air appear to be problematical or impossible, so far as applicable to this meteorite. We cannot understand how the air can bore auger holes into an iron meteroite, and that too in various directions. Some of these small excavations are directed parallel (or approximately so) to the supposed direction of flight; others are nearly at right angles to it. They also branch or anastomose with others. They appeared to the writer to grade, as to form and position in the iron mass, into each other, and to differ only because of the form and position of some different ingredient which once occupied the cavities. It is to the writer very questionable whether any meteorite, in

passing through the atmosphere, becomes heated to the depth of any, even the shallowest, of these cavities. When the Winnebago meteorite fell, one of the three large masses struck in a meadow where the dried long grass was carried by it into the earth. On being exhumed the dry grass had not been consumed, nor charred, but adhered to the meteorite when it was taken out. Another small piece fell on a straw stack but did not set it on fire. This goes to show that the heat experienced by a meteorite when it falls is but momentary, and affects only the surface. It is intense, and fuses the matter of the meteorite superficially forming a glassy "black crust" which is well known; and it goes also to show that such channels and furrows as observed on the Willamette meteorite can scarcely be attributed to heat and friction of the air at the time of the fall. It is difficult to understand why, if these phenomena be due to the heat and friction of compressed air during the passage of the mass through the air, they are confined to the rear surfaces of the mass. It would be reasonable to expect to see the effect of compressed air at the point of greatest compression, i. e., the front side of the mass, but they are entirely wanting on the front. They are most abundant on the rear flat surface.

Again it is difficult to understand why an iron mass should be corroded and rusted out, in the manner assumed by Dr. Ward, by atmospheric air and water after it fell. He assumes that initial rusting points extended themselves so as to form basins and cavities such as seen on the base of this meteorite, the carbonated water once gathered in the depression having eaten into the iron deeper and deeper, expanding its basin on all sides as it goes down. It would be germane to inquire, under that hypothesis. (1) Why the depressions, were not filled with iron rust instead of soil when they were discovered? (2) If the mass was uniform iron, as presumed by this hypothesis, why was it not uniformly rusted all over the surface, even the upper (originally upper) surface which was slightly "crowning" so as to shed water? (3) Why was the edge of the flange eaten into, and even cut entirely through from top to bottom in a few places and not on all sides evenly? (4) Why were those cavities and channels which open on the conical surface and do not

reach the bottom surface rusted out in that way? The acidulated waters could not have been retained in them, being bottom side up. (5) How could the "pittings" on the bottom surface be preserved while the waters with which they must have been brought into contact were eating such enormous cavities in the immediate and contacting iron.* (6) why are the bottoms of these basins always basin-shaped, curving from the sides regularly inward instead of being flat and the sides expanded outwardly to the very bottom?

We prefer to consider all these cavities as due simply to the vacancies left after the removal of other minerals, such as troilite, olivine, enstatite and perhaps other silicates. It is but fair to Dr. Ward to state that he recognizes this possible cause for these cavities. But he plainly does not approve it, since he dwells on the causes discussed by him at length and only mentions this as a possible alternative. Again, the agent of removal of such stony matter he implies was heat and friction at the time of the fall, these materials being considered by him as "softer and more easily yielding to attrition."

On the other hand these cavities have probably all been formed since the meteorite fell, and the manner of removal of the minerals that formerly filled them was oxidation and solution. The shape of these cavities is characteristic. In the association of metallic iron with the usual meteoric silicates the iron usually presents concave surfaces toward the minerals. These concave surfaces come into contact with the convex surfaces of the masses of stony matter. The iron is cellular or spongy with roundish cavities, and runs to points and edges. It appears to have taken shape after the other minerals, or in obedience to the crystalline demands of the other minerals. This is well exemplified by the Kiowa meteorite which was illustrated by the writer in 1890,* and the writer has observed no exception to that rule.

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* The writer saw, many years ago, a slab of Corniferous limestone which had been drawn up from the bottom of lake Huron by fishermen on their nets in the vicinity of Thunder bay, Michigan, which had been corroded by supposed acid waters that entered the lake at invisible springs in the bottom of the lake. Its surface was completely covered with small basin-shaped depressions about 1½ inch in depth and from 1 to 2 inches in diameter, but there was no portion of the original surface remaining.

* AMERICAN GEOLOGIST, May and December, 1890, vols. 6 and 7.

The cavities in the Willamette meteorite are in accord with it.

Further, the minerals that form the stony parts of iron meteorites (and the same is true of stony meteorites) are particularly susceptible to oxidation and total decay. That is probably the reason that by far the larger number of meteorites which have been found, without any knowledge of the date of their falling, are irony meteorites, while by far the larger number of those which have been seen to fall are stony meteorites. If this ratio has prevailed throughout past ages, it argues that the stony meteorites have rotted. It has even been suggested that all or many of the irony meteorites that have been found are merely the irony remnants of former stony meteorites which have otherwise rotted and been converted into soil. The mineral olivine is one of the most easily changed silicates, a fact familiar to all petrographers. It has contributed largely toward the serpentinous greenstones. Its easy decay loosens and promotes the alteration of the other associated minerals. It is a very abundant mineral in nearly all irony meteorites. Troilite is a sulphide of iron. It is easily oxidized, and gives rise to sulphuric acid which powerfully attacks everything adjacent. We do not know what were the minerals that originally filled these cavities, but that they embraced both olivine and troilite is highly probable. Microscopic examination, according to Mr. H. L. Preston (quoted by Dr. Ward), discloses that "there are numerous small troilite nodules from one to three millimetres in size scattered promiscuously throughout the section, and a few rod-shaped ones one millimetre in width and in some instances up to fifteen millimetres in length. The largest troilite nodule found in several sections was twenty-eight millimetres in diameter." This strongly indicates that one of the chief minerals originally in these cavities was trolite, and it may have been the only mineral.

If this explanation of these cavities be correct, it is reasonable to expect that in case a meridional section of the mass is ever made it will disclose some large roundish masses of troilite, which is very likely to be associated with some silicate minerals.

The "furrows" that appear on the brustseite which are referred by Dr. Ward to the heat and friction of the atmosphere, are generally shallower than those on the lower surface. There is no question that such a mass of iron in falling through the atmosphere would lose a considerable amount of its surface by heat and friction. The brilliant trail which is well known to mark the course of a meteorite in falling through the air attests the loss of matter from the meteorite. But it would be very singular if, during the short interval of time occupied by the descent, the air should make such selective "gougings" as are seen on this meteorite.

We cannot perhaps satisfactorily account for the shallower forms of the depressions referred by Dr. Ward to atmospheric pressure and heat seen on the upper side of the iron; but it seems to the writer that they were also once occupied by the same minerals as above mentioned, and that an earlier period in the history of the mass had worn them down or cut them off uniformly with the surface of the iron so that when they entered the earth's atmosphere. these depressions in the iron surface existed but were filled with smaller remnants of the stony matter. It is useless to inquire into the earlier history of this mass, but it must be admitted that it parted from some mass like itself, and its troilite masses must have been rent asunder whenever the plane of separation crossed them. Thus some of the troilites at the present surface may have been shallower than others. Further these shallow depressions are not confined to the brustseite, nor the deep ones to the rear surface. If they were thus distributed there would be more force in Dr. Ward's assumption.

It is needless to say that this iron constituted the most wonderful single object in the mining building. It is the largest meteorite ever found in the United States, and according to Dr. Ward the fourth largest known to science. We cannot but sympathize with those Oregon scientists who wish to have it remain in the state of Oregon, rather than see it transported to some eastern museum.

N. H. W.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

A preliminary list of mastodon amd mammoth remains in Illinois and Iowa. NETTA C. ANDERSON.

On the proboscidean fossils of the Pleistocene deposits in Illinois and Iowa. JOHAN AUGUST UDDEN.

(Augustana Library Publications. No. 5. Rock Island,, Ill. 1905.)

These papers constitute an important addition to the literature of Pleistocene geology. Miss Anderson has gathered the data, so far as the same can be ascertained, concerning all the known instances of the discovery of the remains of these extinct animals in the states of Illinois and Iowa, culling from geological reports and other publications, and from museums and curators such facts as have not been published. The total number of finds is over eighty. Two outline county maps of these states show the geographic distribution of these remains, from which it appears that the mastodon and mammoth ranged throughout these states. In Illinois the localities are rather evenly scattered, but in Iowa they are far more numerous in the southeastern part of the state, usually prevailing along the main river valleys. In the southwestern part of Iowa also is a grouping, suggesting some relation to the great valley of the Missouri river.

These eighty odd finds are discussed by Prof. Udden from four points of view, viz: (1) Conditions of interment; (2) Specific determination; (3) Relation to different drifts; (4) association with other fossils.

In relation to the method and conditions of interment Prof. Udden makes the broad statement, "that the greater number of the animals whose remains have been discovered perished in low and boggy localities, sometimes probably in search for water or salt. These remains have come from stream beds and alluvial deposits, and from terrace and glacial gravels. But most of the fossils have come from the loess or from near the surface of the boulder clay under the loess." Prof. Udden gives the following table of conditions of interment:

SPECIMENS FOUND IN	Number consisting of two or more parts of a skeleton.	Number consisting of single teeth or bones.
Streams or in alluvium..................	2	17
Glacial gravels	1	4
Bogs or near springs......................	17	1
Loess or on Glacial clays	[illegible]	1

As to the specific identification, the following have been expressly identified: Mastodon, Elephas primigenius and Elephas americanus, the first mentioned probably being Mastodon americanus, of which 39 individuals are listed.

The relations these fossils bear to the different parts of the drift sheet as more recently subdivided by the Iowa geologists is plainly one of great interest. Many of the observations were made before the different parts of the drift had been recognized, "and some were even made by geologists who did not regard land ice as necessarily an agent in the deposition of the glacial till." Barring all the uncertainties and imperfections of the record of the data discussed the author still reaches some valuable and interesting conclusions. These conclusions are tabulated below.

AGE	Teeth or tusks only	Bones, mostly with teeth or tusks.
Specimens of unknown age.		
Mammoth	9	....
Elephas primigenius	2	....
Elephant	7	....
Mastodon	13	2
Undetermined	....	1
Specimens of the pre-Kansan (?) or Kansan (?) age.		
Mastodon	....	1
Specimens from the ferretto zone, post-Kansan and pre-loessian.		
Mastodon	....	4
Specimens from the surface of the Illinoian drift, post-Illinoian and pre-loessian.		
Undetermined	1	1
Specimens from the base of the loess, post-Kansan and pre-Iowan.		
Elephant	....	2
Mammoth	....	2
Mastodon	1	....
Undetermined	....	1
Specimens from the loess.		
Elephas americanus	....	1
Mammoth	....	2
Undetermined	....	1
From the area of the Iowan drift, post-Iowan.		
Mammoth	....	1
Mastodon	1	....

AGE	Teeth or tusks only	Bones, mostly with teeth or tusks.
From the area of the Wisconsin drift, post-Wisconsin.		
Elephas primigenius	1	....
Elephant	....	1
Mammoth	1	2
Mastodon	2	4
Undetermined	....	1
From alluvium, mostly sub-recent, but some, perhaps, older.		
Elephas primigenius	....	1
Mammoth	....	2
Mastodon	....	10
Undetermined	....	4

Associated with these mastodon and mammoth fossils have been found also the bones of the buffalo, wolf, peccary deer and elk; also the "land shells Helicina, Succinea, Pryamidula, Bifidaria, Limnæa and others which are characteristic of the loess." "In Rock Island the loess which contained elephant bones also contained fragments of coniferous wood, and at Davenport, in Iowa, the peaty loess from which tusks and other bones were taken has a seam of diatomaceous earth, in which no less than thirty-three now living species of diatoms have been identified."

The discovery of these land mammal fossils in the loess which contains the land shells so often appealed to by those who adopt the æolian theory of the origin of the loess in the Mississippi valley, adds so much more of the same kind of evidence to the support of that theory. It is only necessary to assume that the wind storms that buried the land shells in wind-blown dust and sand were, say, ten thousand times more violent and dust-laden than has been supposed, and that the great land animals that coexisted with the snails were overwhelmed at the same time. And, further, the winds must have been violent enough to rend apart their carcases and to scatter the bones of their skeletons for considerable distances asunder, even extracting the teeth from their sockets. It is a much more natural and simple matter to get the wind-blown dust and the laminated loess into superposition above these fossils than to get the fossils below considerable thicknesses of the laminated loess. The æolian hypothesis accomplishes this in a most admirable and satisfactory manner.

From the foregoing table it is learned that the mastodon and the mammoth existed, perhaps, prior to the Kansan ice epoch, and continued into the Iowan epoch, into the Wisconsin and even into

the sub-recent, having become extinct perhaps not more than five thousand years ago.

As to man and the elephants, these data give no direct testimony that they were cotemporary, except in one instance. Mr. M. T. Myers, of Fort Madison, reports the finding of "one human leg bone and one flint arrow head" associated with the remains of the mammoth in the alluvium of Lee county, Iowa. This is in the region where so-called "elephant pipes" have been claimed to occur in mounds constructed by earlier inhabitants of the country. "At all events the evident recency of some of the proboscidean remains makes us expectant of some fortunate discovery giving conclusive proof that man lived on this continent while these huge mammals were yet here." N. H W.

Indiana Department of Geology and Natural Resources. 29th Annual Report. W. S BLATCHLEY, State Geologist, pp. 1-888; pl., 34; figs., 67; maps, 7; Indianapolis, 1905.

In the introduction to this report Prof. Blatchley reviews the development of the natural resources of the state during the past ten years. During 1895 the total output of coal, oil, gas, building stone, clay-products and portland cement was $16,770,816, while in 1904 the total output of these same products was $36,028,755, or an increase of 115 per cent.

The body of the book is made up of an article on "The Clays and Clay Industries of Indiana" by W. S. Blatchley. In the opening chapter he treats of the technology of clay. The geological distribution of Indiana clays forms the subject of the second chapter which is followed by "The Clays of Indiana by Counties" in which the clays within five miles of transportation lines are taken up and discussed in detail. Analyses are given and suggestions made as to the possible utility of individual deposits. These are frequently accompanied by maps and halftones of the exposures. In the fourth chapter, the clay working industries of Indiana, he discusses the growth of the clay-working industries of the state from $3,858,350 in 1900, to $6,085,242 in 1904, and gives in detail the methods and processes of manufacture, tests and uses of the products made from Indiana clays. These include paving material, sewer pipe and hollow wares, refractory products, pottery and allied products, dry pressed brick, structural terra cotta, building brick and tile and the production of clay for shipment. This article is calculated to be a practical aid to the development of the clay resources of the state and, while a larger number of maps would have added to its value, yet, it serves that end admirably. It is intended largely for the use of the layman and is couched in the clear simple language characteristic of the author.

The remaining quarter of the book contains five articles, the first of which is the report of the mine inspector, James Epperson. This shows the total output of coal for 1904 to be 9,872,404 tons against 9,992,553 tons for 1903. The next article is the report of

the gas inspector, Bryce A. Kinney, which is followed by a short article by Prof. Blatchley on the utilization of convict labor in the making of road material. The petroleum industry of Indiana, by Blatchley, concludes the geological part of the book. He states that "The output for 1904 was greater than in any previous year, both in the number of barrels produced and in value, though the average market price declined nearly seven cents. Since 1898 each year has seen an increase in production, and in the seven years has more than trebled." The most important development during the year was in the Munsie-Parker-Selma field where a third "pay streak" was discovered 240 to 300 feet below the top of the Trenton rock at this place. The output for 1904 was 11,330,030 barrels valued at $12,127,107. The last article is by Melville T. Cook on the "Insect galls of Indiana." J. W. B.

MONTHLY AUTHOR'S CATALOGUE

OF AMERICAN GEOLOGICAL LITERATURE ARRANGED ALPHABETICALLY.

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CORRESPONDENCE

Economic Geology in Peru.—It might be of some interest to the readers of the American Geologist to learn something about the scientific organization recently created by the government of Peru to investigate the natural resources of the republic. Owing to the very rapid development of the various mining industries, the establishment of a bureau which should be authorized by the government to locate and fix boundaries of mining claims, collect statistics relative to the production and values of ores, and accumulate various data relative to the geology, mineralogy, and geography of the country, became an immediate necessity. Accordingly in 1902 the bureau now known as the "Cuerpo de Ingenieros de Minas del Peru" was established with Sr. J. Balta, the present minister of public works, as the director. It was soon discovered however, that the subjects and projects demanding the immediate and serious consideration of this organization were so numerous and varied in kind, that it became highly advisable to classify the work in hand and distribute allied lines of investigation to independent commissions each with its chief and corp of assistants, the series of commissions, however, being under the general charge of the Director of the "Cuerpo," Sr. Marco A. Denegeri. The divisions of the "Cuerpo" are as follows:

1. Division of Mines, established 1902, including:
   (a) *Permanent* commissions in large mining areas, to locate claims, fix boundaries, etc.
   (b) *Exploratory* commissions to investigate and report upon newly discovered mining areas.
2. Division of Water Supply, established 1904, including:
   (a) *Engineering* projects relating to the storage and distribution of surface water for irrigation purposes.
   (b) *Geological Investigations* to determine location and distribution of underground waters.
3. Division of Economic Geology, established in 1904.

All these commissions have their responsible chiefs and one or more assistants and among these chiefs are four American specialists, namely, Dr. George T. Adams, in charge of underground waters, M. H. Hurd and Chas. W. Sutton for engineering and topographic work, and Mr. V. F. Marsters for economic geology. The only non-Peruvian technical assistant is Mr. H. T. Stiles, who is under the direction of Mr. Hurd. At this time there are at work:

2 Permanent mining commissions.
6 Exploratory mining commissions.
1 Economic geology commission.
2 Topographic and water-supply commissions.
1 Underground water commission.

Generally the names of the permanent commissions are taken from the districts in which they are located, e. g., the Cerro de Pasco, Yauli Ica, Callao, etc. commissions. Each commission is allowed a certain sum of money which is under the direct control of the responsible chief.

The object of the geological commission is to investigate specific problems relative to the development of the metallic and non metallic deposits of Peru. This department constitutes the first official geological survey in the republic. The first problem to be considered will be the geology of the oil fields of northern Peru (Province of Tumbes.)

While the "Cuerpo" has been in existence but a little over three years some twenty-six bulletins dealing with a wide range of subjects have been published. These may be obtained by application to the Director, Sr. Denegeri.

Lima, Peru, Sept. 12, 1905. V. F MARSTERS

MATEO TEPEE —A little over a year ago, while going over several new works, the writer was struck by the many ways in which the several authors had in spelling the same words. Several instances were noted, but one of the best illustrations was that of a volcanic tower in the northeastern corner of Wyoming—"Mateo Tepee," or what is more popularly known as the "Devil's Tower." This tower of perpendicular basaltic columns, may be seen to the right of the Burlington railroad in going west, between New Castle and Sheridan, Wyoming. According to Newton and Jenney, it has an elevation of 625 feet from the surrounding country and may be seen for many miles around.

Professors Chamberlin and Salisbury spell it in their new Geology, page 136, fig. 124, "Matteo Tepee," locality Wyoming.

Prof. R. S. Tarr, spells it, in his "New Physical Geography," fig 231, facing page 127, "Mato Tepee" locality Wyoming.

In the May number 1904, of the AMERICAN GEOLOGIST, under the title of "Editorial Comment, Peleliths," plate 22 facing page 324, the same name is spelled "Mato Teepee" and the locality given as South Dakota.

In the "Report on the Geology and Resources of the Black Hills

of Dakota" by Henry Newton and Walter P. Jenney, 1875, published 1889, it is spelled again Mato Teepee and the locality given as Dakota—i. e. one would infer as much from the title of the report. However, a map of the Black Hills was prepared by these gentlemen and accompanies the report, and shows the tower to be in Wyoming. At the time this report was made the tower was called "The Bad God's Tower" or in other words "The Devil's Tower."

The boundary line between South Dakota and Wyoming is a little west of 104° or about 104°-1′20″. "Mateo Tepee" or "Bear Lodge" as Newton and Jenney called it, is located on their map at almost exactly 104° 45′ W. Long. and 44° 35′ N. Latitude. This places it in the northeast corner of Wyoming, in Crook county.

The name, "Mateo Tepee," is of course of Indian origin, probably from the Sioux, and literally means "Bear Wigwam"—Mäteo, pronounced Mäh-to—meaning bear and " Tepee" meaning wigwam, lodge, or a conical tent. In former days this region (around the Devil's Tower) was a great bear country and was visited each year by the Indian bear hunters—hence the name.

In conclusion the writer believes this name should be spelled "Mateo Tepee" and the locality is without a doubt in Wyoming.

J P Rowe

University of Montana, Missoula,
September 21, 1905.

PERSONAL AND SCIENTIFIC NEWS.

Illinois Geological Survey. At the last session of the legislature a bill was passed establishing a geological survey of the state and making an appropriation of $25,000 per year for this purpose. Of this amount $10,000 may, at the discretion of the board of control, be used for topographic mapping in cooperation with the U. S. Geological Survey. This cooperative work has been undertaken for the present year, at least, and work along this line was begun about the first of June. The board of control consists of the governor of the state, the president of the State University and one other member to be appointed by the governor. Gov. Deneen this summer appointed as the third member of the board Prof. T. C. Chamberlin. The headquarters of the survey are to be at the State University at Champaign and the University furnishes rooms for the survey. For printing, etc. $5,000 is available from the state printing funds. Dr. H. Foster Bain, of the U. S. Geological Survey has accepted the position of state geologist and enters upon this work November 1st.

UNIVERSITY OF WISCONSIN. During the coming January Mr. Bailey Willis, of the United States Geological Survey and Carnegie Institution, will present a course of twelve lectures in the Geological Department of the University of Wisconsin on the subject of "Continental variations, with special reference to North America." The course is given primarily for students making geology a major study, and is open to such students not regularly registered at this university.

IN THE YEAR 1904 THERE WERE OBSERVED in Norway 35 earthquakes, of which the most severe was on the 23rd of October, and more than half of the whole number occurred after that date.—Kolderup.

DR. U. S. GRANT RETURNED from Alaska, passing through Minneapolis in the early part of September, in time to resume his work at Northwestern University.

DR. W. J. MCGEE HAS BEEN APPOINTED DIRECTOR of the Public Museum at St. Louis.

THE LAKE SUPERIOR MINING INSTITUTE will hold its eleventh annual meeting on the Menominee range at Ishpeming, Mich., October 17, 18 and 19. There will be trips by train to Crystal Falls, Iron Mountain, Escanaba and Gladstone.

PROF. CHARLES SCHUCHERT of Yale University, has returned from a geological trip extending over the ancient formations of Nova Scotia, New Brunswick and eastern Quebec.

E. H. SELLARDS late of the University of Kansas, is in charge of the departments of zoology and geology at the University of the state of Florida.

W. J. MILLER HAS BEEN APPOINTED to succeed professor C. H. Smyth Jr, in geology, at Hamilton college, and M. W. Twitchell has been appointed to the chair of geology at South Carolina college, Columbia, S. C.

PROF. C. N. GOULD of the University of Oklahoma, will be absent the current college year and his duties will be discharged by Prof. E. G. Woodruff.

CHARLES W. BROWN has been appointed instructor in geology and mineralogy at Brown University.

Quarry in a Glacially Transported Mass of Chalk, near Malmö, in Southern Sweden.

[Photograph by Dr. N. O. Holst.]

THE

AMERICAN GEOLOGIST.

VOL. XXXVI. NOVEMBER, 1905. No. 5.

GLACIAL MOVEMENTS IN SOUTHERN SWEDEN.

By Prof. G. Frederick Wright, Oberlin, Ohio.

PLATE XIV.

Having had the privilege of spending two or three days with Dr. N. O. Holst, while he was engaged in surveying for the geological map of Skane, the southern province of Sweden. I am permitted to bring before the English public some of the important and remarkable discoveries which he has made. These relate first to the direction and force of the ice movement, and secondly to the unity of the period.

Skåne, the most fertile province of Sweden, projects southward of the main peninsula so as to make it almost a part of Denmark, to which by virtue of its physical geography it properly belongs. It is completely covered with glacial deposits to a depth of 100 or 200 feet. A very well defined terminal moraine runs across the province east and west, about midway between the north and south boundaries.

The material in this moraine is to a considerable extent derived from Finland, showing that the center of glacial dispersion was somewhat farther east in Scandinavia than has been supposed. Both the direction of the moraine and the material of which it is constituted show that in southern Skane the final ice movement had a northwesterly direction. That is, the ice, after moving down the axis of the Baltic sea in a southwesterly direction, when it passed the low mountains bordering the northeastern part of Skane, must have found the line of least resistance in the direction of the North sea, causing it to turn around towards the north,

as the lake Erie ice is known to have done in southern Michigan and northern Indiana.

The most striking indication of this is found in the position of an immense mass of chalk which is included in the moraine about five miles east of Malmö. This chalk mass extends three miles in a northeast and southwest direction, averages 1,000 feet in width, and from 100 to 200 feet in thickness, being, so far as I know, the largest boulder, or glacially transported mass, that has been described. It is everywhere covered with till, and almost everywhere has till underneath it. Its regular position is between what we should call the upper and the lower till, the upper till being yellow and the lower blue. But in one place, which I examined, the lower or blue till was both above and below it.

While the chalk is together in one mass, it everywhere shows signs of immense pressure and disturbance, being broken up into small cubes, and having its flint nodules cracked and arranged in lines simulating stratification. The upper part of the chalk has also been extensively sheared off and mingled with the till.

This mass of chalk has been brought fully to light through its commercial value, eight or ten companies having mined or quarried it for many years. It belongs to the true soft chalk of Cretaceous age, and was supposed by the earlier geologists to indicate a Cretaceous area, where it was least to be expected, since the chalk which mainly underlies the peninsula belongs to the Trias or Lias. The determination of its glacial transportation has therefore solved a very difficult problem. It must have been picked up bodily from the shores or bed of the Baltic sea, being transferred westward many miles to its present position.

Dr. Holst is bringing to light much new evidence bearing upon the unity of the Glacial period, and is more than ever confirmed in his adhesion to the theory that the upper till and the lower till are of the same age,—the lower till being that which was dragged along under the ice, and the upper till the material which was incorporated in the ice, and which so became oxidized in the process of transmission and deposition. In many cases which he showed me, this would certainly appear to be the fact, as indicated

by the sharp line which separates the blue from the yellow till.

But the most important discoveries bearing upon this point were found at Tapplelargo, twelve miles east from Malmö. Here is an area of several acres covered with an overwash deposit from the moraine, which is a mile or more to the south. In a stratum of clay, about seven feet thick, many species of shells and plants are found, indicating peculiar conditions which can be accounted for only by supposing that during the final melting away of the ice the summers became very warm, so as to allow temperate species to flourish close up to the ice-front, thus allowing them to mingle with arctic or subarctic species.

It is evident from inspection of the stratum that these species lived and were deposited contemporaneously, and not by an advance of the ice after an interglacial period. This would seem to meet the case of comingling of temperate and subarctic species which Coleman has described in the vicinity of Toronto, and so it will greatly simplify our interpretation of glacial phenomena in the northern United States and Canada.

BOLSON PLAINS OF THE SOUTHWEST.

By W. G. Tight, Albuquerque, N. M.

There seems to be a very decided tendency on the part of students in physiographic geology to enlarge upon the conceptions of topographic types, as they are originally described, and in the subsequent study of the topographic features of any particular section, to describe those features in terms of the modified conception of the type forms.

As a result there develops a very confused idea in the minds of workers concerning the true type, and with that misconception in mind the correct interpretation of any particular region becomes doubtful, and the description of that region almost wholly unintelligible, giving to the student who has access to the literature alone, a radical misconception of the true topographic conditions.

As an example of my meaning the term "peneplain" may be taken. It would be interesting to know how many times

an aggradation plain of some sort has been mistaken for a degradation plain and called a peneplain. There are undoubtedly many cases where the two types of plains look nearly alike and only a careful study would determine the true character.

This superficial resemblance, which extends to various types of topographic forms, is a constant source of error. The most serious mistakes are made when two types of radically different origin and structure are classed together and made the basis for broad generalizations.

When an author has described a certain type of topographic form, presumably from a careful study of some definite region, and has given a name to that type, it can only lead to much confusion and error when the same name is used by another to describe a different form, or to attempt to modify the meaning of the term to fit other conditions.

It is not intended at the present writing to discuss the uses and abuses of he term "bolson" as applied to intermontane valleys but rather to take the term as originally described* and apply it to the study of the great valleys of the southwest and especially to New Mexico.

To quote briefly: "Bolsons are generally floored with loose, unconsolidated sediments derived from the higher peripheral regions. Along the margins of these plains are talus hills and fans of boulders, and other wash-deposits brought down by mountain freshets. The sediments of some of the bolsons may be of lacustral origin." "The bolson plains on the other hand," (as distinguished from plateau plains) "are newer and later topographic features, consisting of structural valleys between mountains or plateau plains, which have been partially filled with debris derived from the adjacent eminences." "The bolson plains are constructional detritus plains filling old structure troughs."

It seems that this description is clear enough. The type form is not dependent upon the characters of the bordering mountains nor the character or structure of the deeper valley floor, nor is it especially concerned with the total thickness of the wash-deposits over the floor of the

*Hill, Top. Atlas, U. S., folio 3, p. 8, 1900.

older valley, except in so far as these deposits must contribute an important factor in determining the characteristics of the topography. An important element in this definition depends upon the interpretation of the word "plain." A bolson is genetically related to other constructural plains, such as flood plains and terrace plains of river valleys. In the flood plain and terrace plain deposits the plains are more or less narrow and parallel with the stream, which furnishes the major portion of the deposits. On the other hand in the bolson, while the deposits are of fluviatile origin (or largely so) the plain loses the characters of a flood plain or terrace plain in that it is generally much broader and the material "is derived from adjacent eminences," and the plain is of such an extent that the "talus hills and fan cones and wash-deposits brought down by the mountain freshets" form only the bordering characters of the plain, but point unmistakably to the origin of much of the deposits forming the floor of the bolson.

If we look for a moment at the forces involved in the formation of a bolson we see that there must exist an extensive trough in which the contribution of material from the sides of the bordering mountains is much greater than the capacity of the pre-existing drainage to remove, or that in the structural formation of the valley there is formed a closed basin and into this the lateral materials are deposited. In the closed basin type, the basin may or may not be the location of a lake. If the older trough has free drainage to start with the lateral introduction of debris may be such as to divide an otherwise continuous stream course into a series of lake basins or to even totally obliterate the through-flowing stream as a surface feature.

Mr. Hill says: "These plains or 'basins' as they are sometimes called are largely structural in origin," and again he uses the terms "structural valleys between mountains and plateau plains." If it were intended to confine the term bolson to those forms which occur in strictly structural valleys which have not been subsequently modified by erosion, it would have a very limited use indeed, for but few valleys of that type are to be found, and the author's illustrations do not indicate this limited use. But I take it

that the term "structural valley" or "structural trough" was used in reference to the large features of the topography as distinguished from simply valleys of erosion cut mainly by stream action. The very essential feature of a bolson is that the plain is bordered by mountain forms or plateau escarpments. The mountains may be of the fold or fault type, but rising as they do above the general level of the plateau upon which they stand the intervening area might properly be considered a structural valley. In some cases this intervening area may be so protected from erosion by the distribution of the mountain uplifts that it will be preserved and will present the structural characters of the original plateau plains. Again it may be in the line of the great longitudinal drainage lines of the plateau and be largely removed by subsequent erosion. As far as the later formation of a bolson is concerned, it would appear that either type might properly be called a structural valley, and with the later deposition of the detritus forming the bolson plain, there would be a striking difference in the thickness of the deposits, those in the eroded structural valley being much thicker.

It would appear also that in the formation of such a structural valley by the enclosure of a portion of a plateau by the elevation of bordering mountains, where the valley is not subjected to subsequent erosion and the remaining valley floor is fairly horizontal, there would be produced a topographic form which would resemble very closely the bolson but which would be as essentially different from it as an aggradation plain is different from a peneplain. These two forms having similar superficial characters may be easily mistaken, the one for the other, for with the elevation of the bordering mountains enclosing a structural valley free from erosion, there will most certainly develop around the margin of the remnant of the enclosed plateau plain, talus hills and fan cones and frontal wash aprons which will rapidly work out over the floor of the valley and eventually convert it into a bolson plain while the superficial characteristics may remain almost the same during the entire process.

It is apparent that when the filling of the valley takes

place over the floor of the great structural valley, the production of the bolson does not materially modify the topographic features, but when the great structural valley has been deeply eroded and then subsequently filled the production of the bolson does make a decided difference in the topographic relations of valley and mountains. We see then, that the bolson plain finds its proper place in the series of constructional plains derived from fluviatile actions, and the lowest member of the series is represented by the flood plain of the river, in which the material is almost wholly derived from the longitudinal action of the stream; while the bolson plains are at the opposite end of the series, in which the longitudinal stream may contribute largely in some stages of the building of the plain but that the predominant factor is the derivation of material from the bordering hights by torrential action of temporary streams and rivulets which are produced largely by rainfall.

This in general is the writer's understanding of the use of the term bolson, as applied to many of the great intermontane plains of the southwestern plateau and great basin region. Whether the writer is correct or not in his interpretation of the use of this term, it is certain that under any definition of the term there is found in this region a large number of valley plains having very diverse characters and very diverse origins. The writer cannot therefore agree with Dr. Chas. R. Keyes of Socorro, in his discussion of the bolson plains of New Mexico in the AMERICAN GEOLOGIST for September, 1904. Dr. Keyes has grouped under this term such plains as the Jornada del Muerto, San Augustine, Estancia, Mimbers and the great plains along the Rio Grande, Rio Pecos and Canadian rivers. He has seemed to correlate these plains, with others, with the great Llano Estacada of Texas and other great plains to the southwest. If Dr. Keyes' correlations are correct, it does not seem to the writer that these great intermontane plains of the New Mexico region can be by any definition classed as bolson plains and many of them certainly conform to that definition. In view of this difference of opinion it seems advisable to call attention to some of the features of some of these various plains in detail. It is well understood that the

great stake plains of Texas are made up largely of Cretaceous sediments which have a more or less regular dip from the frontal ranges of the Rocky mountains to the gulf of Mexico. Toward the New Mexico border of this plain the strata have stronger dip and erosion has exposed the edges of the strata along the Rocky mountain front. The Cretaceous terranes are covered with a mantle of Tertiary gravels derived from the mountain front.

Dr. Keyes says: "The Las Vegas plateau, Llano Estacada, the bolson plains of New Mexico, and some of the broken plains of eastern Arizona seem to belong genetically together;" and he further says: "When the general bowing up of the region took place in Tertiary times, the great plain formed was partly a pleneplain of destructional land origin and partly a constructional plain of marine origin." From this it would appear that the bolson plains of New Mexico, as he describes them, are remnants of this old peneplain, and that the mountain blocks of the plateau of New Mexico were formed subsequent to the peneplanation of the Cretaceous and lateral beds. It is not possible at the present writing to present the data to show that the structure of the mountains of New Mexico will not sustain this position. It is the writer's desire in this discussion, to confine attention wholly to the valley forms.

Dr. Keyes says: "That the old bolson plain in the Rio Grande valley is at present about 1,500 feet above the river" and he refers to the Colorado river as being "a mile deep in its canyon" below the surface of the great plain which he has constructed in his hypothesis.

During a residence of four years in the Rio Grande valley, accompanied with considerable field work, it has not been my pleasure to see a single remnant of the old plain to which reference is made. The valley of the Rio Grande through New Mexico has an extremely complex and varied form, and history. I desire at the present writing to call attention to only a few points in its history bearing upon the particular discussion in hand, and what is said with reference to the valley includes only that section which lies within the territory of New Mexico. The river is at several points, notably at White Rock canyon, at Elephant buttes,

and at El Paso, cutting through a rock gorge upon a rock floor, but throughout most of its course it is meandering over a broad flood plain in a still broader shallow trough, the latter cut some 200 or 300 feet below the surface of the broad sheet of plain deposits locally known as mesas. The larger structural valley which is followed by the Rio Grande is undoubtedly of very complex origin and no general description would be adequate for any particular section of the river. From the limited amount of data in hand it would appear that in some sections the river is following the line of a great fault zone and in other sections it is apparently following along the axis of an immense anticline, which has been very deeply and broadly eroded. The great structural valley presents an average width of fifteen to twenty miles, measured across the surface of the great mesa plain.

If we examine into the structure of the mesas bordering the river, as presented by well sections and deeply cut arroyos, we find that it is made up wholly of sands, gravels, and clays of fluviatile origin. The materials composing the mesas have been largely derived from the lateral mountains. The depth of this mesa deposit in the old structural valley is not definitely known. A well over seven hundred feet deep at Albuquerque did not reveal the rock and as the top of this well is about 250 feet below the surface of the mesa plain and near the central portion of the great valley, we can see that the great structural trough has been filled by the mesa deposits to the depth of probably much more than a thousand feet. It is evident from many topographic features that the river once meandered over the upper surface of this mesa plain at least 250 feet above its present level. At about that time in the history of New Mexico there occurred a more or less general extrusion of basaltic lavas over many areas. At least two of these lava overflows reached down into the valley of the Rio Grande and attained such magnitude as to produce profound changes in the course of the river. The first of these which I will mention is the great lava flow in northern New Mexico which dammed the course of the Rio Grande above the White Rock canyon, and the second, the great lava flow south of San

Marcial, which deflected the course of the Rio Grande far to the west of its old valley through the Elephant Butte canyon and west of the Sierra de los Caballos, reaching its old course again just a little north of Las Cruces. The Jornada del Muerto lying between the San Andreas and the Sierra de los Caballos is undoubtedly the old valley of the Rio Grande, from which the river was diverted at the time of maximum aggradation and at the time of the great San Marcial lava flow. There is every reason to believe, from a careful study of the history of the Rio Grande that a cross section at the Jornada del Muerto is comparable in its history to a cross section of the river at Albuquerque, where the mesa deposits are known to be at least a thousand feet in depth. It is therefore evident that the plain of Jornada is in no way genetically related to the Llano Estacado, except in so far as concerns the Tertiary deposits of the latter. That the great mesas bordering the Rio Grande are wholly of fluviatile origin is further shown from the topographic characteristics in the vicinity of El Paso where the river runs through a narrow rock channel between the Franklin mountains and the range to the southwest.

Some few miles above El Paso, and on the west of the Franklin mountains are preserved other extensive remnants of the old gravel and talus plains which extend out from the canyons of the Franklin mountains at a level of 300 or 400 feet above the Rio Grande. Several miles to the west across the immediate channel of the Rio Grande are seen the opposite exposures of the same beds. Whether it was by the blocking of the old channel with another lava flow farther to the west or by the normal process of excessive aggradation, that the Rio Grande was forced through the narrow mountain pass at El Paso is yet undetermined, but that it is superposed in its present position upon an ancient col at El Paso is certain.

The second instance to which attention is directed is the great basin in New Mexico lying between the San Andreas and the Sacramento mountains, known as the White sands plain or the Hueco bolson.* This certainly is a typical bolson as the writer understands the use of the term. These

* Hill, U. S. Folio, No. 3, p. 9.

great plains are some sixty or seventy miles long and twenty to thirty miles wide with the Sacramento mountains on the east rising to an average level of 6,000 or 7,000 feet above the plains and the San Andreas and Organs on the west and the Sierra Oscuras on the north rising to a somewhat less elevation. The plains are very level or slightly depressed through the central axis and show a decided grade toward the south. In the upper part of this great plains valley are the white sands and the salt marshes of the ancient lake Otero basin recently described by Prof. C. L. Herrick, late of Socorro, New Mexico, in the September number of the GEOLOGIST 1904. At the northern end of the plains lies one of the most extensive lava flows in New Mexico, surpassed only probably by the great northern lava flow in Ria Arriba and Taos counties, and in western Valencia county. That the deposits forming the floor of this great basin are very deep and composed almost entirely of fluviatile material has been demonstrated by numerous wells which have been sunk through various portions of the plain ranging in depth from a few feet to a well in the southern portion of the plain over 2,000 feet deep, which did not even at that extreme depth reveal the rock.

North of the great lava flow lies the Chapedero mesa and still farther north of that are the Estancia plains (Sandoval bolson of Hill). While it cannot be definitely asserted with the data in hand, there are many facts which would seem to indicate that the Estancia plains and the white sands plains represent a g reat north and south structural valley, more or less parallel to the Rio Grande valley, from which the ancient river which occupied it, was either diverted by the extensive lava flows or by the normal processes of aggradation, or, what also seems very probable, that the sediments of the great bolson plains in these great structural valley sections have reached such enormous thickness that the waters of the through flowing drainage are at present entirely subterranean. There are many facts in hand to prove that there is a subterranean drainage which passes out of the southern end of this great axial trough.

In referring to the region of the Rio Pecos, Dr. Keyes says: "Of these the last two streams mentioned" (Rio

Pecos and Rio Grande) "flow in the broad valleys between lines of block mountains," And in another place refers to the long basin plains of the Pecos and states that the Pecos has cut down to a depth of 2,500 feet below the level of the old plain. It would seem that Dr. Keyes has failed to recognize the fact that the Rio Pecos derives most of its water supply from the eastern side of the ranges of the Rocky mountains; that the drainage of the river corresponds very closely with the strike of the Cretaceous beds, the Pecos itself being a very asymmetric river, having all of its tributaries of any consequence on its western side. And when it is borne in mind that the river is flowing in its southern course through southeastern New Mexico along the outcrop of a great bed of gypsum and that the Cretaceous terranes of the Llano Estacado are dipping to the eastward it will be seen that in the development of the Pecos valley the axial stream has been migrating slowly eastward down the dip of the strata against the edge of a hard stratum. On the westetrn side of the Pecos the surface of the region conforms very closely with a very hard limestone element of the Cretaceous series which rises rapidly toward the west nearly to the crests of the bordering mountains, while on the eastern side of the river there is a sharp escarpment of a few hundred feet from the upper edge of which extends the great plain of the Llano Estacado, which slopes gradually to the southeast, the surface of which is strewn with the Tertiary gravels. The Rio Pecos, therefore has no mountains bordering the eastern side of its valley and there are no extensive detrital plains in any way comparable to those of the Rio Grande along the course of the Pecos outside of the mountain valleys at its head waters, except the great frontal apron of Tertiary mountain wash just referred to.

If we are to assume that two thousand feet of sediments have been removed from the Llano Estacado then it might be proper to say that the Pecos is flowing 2,500 feet below the aggradation surface of the Cretaceous terranes; otherwise we must consider that the major portion of the valley of the Pecos is scarcely more than a good sized drainage ditch along the line of strike of the hard beds of the Cretaceous formation which underlies the Staked Plains region.

Concerning the bolsons of the Rio Mimbres or Antelope plains I have little data at hand except that it is well known that underneath the Antelope plains there is a large supply of subterranean water contained in deeply buried river gravels. It has never been my pleasure to visit the San Augustine plains, therefore I cannot speak authoritatively concerning this extensive bolson.

With this brief statement concerning some of the physiographic and structural features of New Mexico it seems to the writer that Dr. Keyes is not justified in classifying as a common physiographic type the great plains of the Llano Estacado to the eastward of New Mexico and the typical bolsons which occur within its borders. In the judgment of the writer it would not even be possible to place the border plains of the Rio Grande and of the Rio Pecos in the class of bolsons, and certainly such plains as the Hueco, Mimbres, the Estancia and the Jornado can bear no relation whatever to the great plateau plain through which the Colorado river has cut its grand canyon.

From the data in hand it appears to the writer that in New Mexico and much of the great basins region where the bolson plains form an important physiographic type, there is a common history of origin. The whole region has been at some time at a very much higher level than at present and subjected to such erosion that the great structural valleys of the entire region were worn out several thousand feet in depth. Every feature of origin seems to point with unmistakable finger to a time of such erosion, under atmospheric conditions of heavy participation, with a much higher elevation of the plateau than at the present time. There certainly was a time when the carrying capacity of the axial streams of all the valleys was much in excess of the loads of material furnished to them by their lateral tributaries and by torrential action of the characteristic method of precipitation of the semi-arid region, resulting in the supply of enormous quantities of material from the steep mountain slopes into the valleys in such quantities that the larger streams were vastly overtaxed and the period of aggradation was inaugurated. This period continued until the deposit in these ancient valleys accumulated to thousands of feet

in thickness. In many cases the valleys were so completely filled that the detrital plains of the neighboring valleys were united, giving the appearance of extensive plains with isolated islands or bordering ridges.

Where the flow of water in the larger drainage axis like the Rio Grande was sufficient, the river contributed largely in the process of aggradation and plains building.

At or near the time of maximum aggradation, in the New Mexico region, at least, occurred the period of great basaltic lava flows. These were so distributed that in some cases, the lava flowed on to the bolson plains of the great isolated valleys or into the great plains bordering the Rio Grande and other streams diverting their courses. This great period of subsidence and aggradation is most strikingly shown in portions of southern Arizona, where Dr. W. T. Lee of the Geological Survey, has told me that the fluviatile deposits following the great eroded channelways of the Colorado and other streams extend to several hundred feet below sea level as is abundantly attested by well data.

While it does not seem at all necessary to postulate the great deformations of the land to account for transitions from conditions of degradation to those of aggradaation, as in many cases variations of climatic conditions including precipitation and so on, may be sufficient causes, yet where it is known that the plain of degradation extends below the plain of the present marine base level, a difference in altitude must be assumed. Dr. D. W. Johnson in an extensive article on the High Plains and Their Utilization, published in the 21st annual report of the United States Geological Survey, Hydrographic Division, has described with much detail the method of the formation of the frontal aprons bordering the mountain areas in the semi arid regions with special reference to the great sheet of Tertiary gravels which are spread out over the high plains region, including the Llano Estacado. He presents a diagramatic section on page 729 of that report showing the relation of Tertiary gravels to the underlying Cretaceous over the Stake Plains plateau, and he rightfully, I believe, attributes their origin to the frontal ranges of the Rockies. His description of the method of formation and structure of the great Tertiary

plains is in accordance with the writer's views upon the same subject, and present the conditions which prevail throughout the western plateau and great basins region during a portion of Tertiary time.

That there is certainly a great similarity in the method of formation of the Tertiary deposits over the Llano Estacado and great bolsons of New Mexico, and the basin region there is no question. The same attitude of the land under uniform climatic conditions produced throughout the entire southwestetrn country more or less uniform phenomena of erosion and aggradation on the pre-existing land forms, but that the term bolson is to be applied to any and all portions of these deposits wherever found is to be much questioned. The same conditions which spread out a great sheet of gravels over the surface of the Cretaceous on the Llano Estacado produced an extensive filling in all the great mountain-bordered basins and erosion valleys of the plateau region.

Nor can we class as bolsons such plains of recent origin as occur along the Rio Grande, which have been described by Dr. Herrick, in the GEOLOGIST, vol. 33, June 1904, as clino -plains.

If we are to consider the section of the Rio Grande between Bernalillo and Socorro, the Jornado del Muerto, and the Mesilla valley as typical bolsons as described by Mr. Hill, and are also to consider the Roswell basin of the Pecos as a typical bolson, it seems certain that the Roswell bolson, so classified, must be of a much more recent origin than those of the Rio Grande, for the Rio Grande deposits seem to be correlated in time with the great Tertiary deposits over the surface of the Llano Estacado, while the deposits occupying the Roswell basin have been made since the erosion of that basin out of the Tertiary and Cretaceous formations of the Llano Estacado. Again if we are to confine our definition of the term bolson to plains formed within the structural valleys (using this latter term in a very broad sense)then we must exclude the Roswell valley from the class of bolsons, for the writer is satisfied that the section of the Pecos included within the borders of New Mexico is wholly an erosion form.

In no sense then can the extensive bolsons of New Mexico be grouped into a common class and referred to as remnants of the early Cretaceous peneplain preserved "merely by lack of erosion agencies." We must then take sharp issue with Dr. Keyes, when he says of the bolsons of New Mexico: "Bolson plains may be considered as sections of an upraised peneplain surface in its earliest infancy, in the stage when they are as yet untouched by stream action."

As a bolson plain is a constructional form and is not confined necessarily to any period of time it must be recognized that the bolson plain passes through a history of construction and destruction similar to that of any other constructional topographic form, and the various stgaes of its formation and destruction should be carefully noted. After the formation of the bolson plain the region may become subjected to intense erosion, which would eventually leave but remnants of the old plain, while a neighboring plain not subjected to such treatment might persist or even continue to develop its characteristics as a distinct physiographic type.

It seems to the writer that the bolson plain will find its proper place and recognition in the literature of topographic forms.

GLACIAL LAKES AND MARINE SUBMERGENCE IN THE HUDSON-CHAMPLAIN VALLEY.

By WARREN UPHAM, St. Paul Minn

Very important studies of the Quaternary history of the Hudson-Champlain valley have been recently published by Charles E. Peet and J. B. Woodworth, who have worked mainly, both in the field and in the study, without collaboration together, yet reaching closely similar conclusions.*

The work of Mr. Peet is a continuation from his service since 1893 on the Geological Survey of New Jersey, for which he mapped the Pleistocene deposits of the Palisade Ridge, bordering the Hudson river. His plans for extending this investigation along all the valley north to lake Champlain and the St. Lawrence were made under the direction of Prof. R. D. Salisbury, and the field work and presentation of results have been directed by Prof. T. C. Chamberlin; but the author claims the full responsibility for the opinions expressed. He had reached the main results some four years ago, and later gave attention chiefly to the crustal movement and the origin of the water body in the Hudson valley, whether lacustrine or marine.

Professor Woodworth gives in his two very elaborate publications the results of his surveys for the New York State Museum during the years 1900 to 1903, with the aid of field notes and advice by G. K. Gilbert from several seasons of his work in the St. Lawrence valley, where he had examined the country from lake Ontario around the northern slopes of the Adirondacks and southward on the west side of lake Champlain to West Chazy. That exploration led to the selection of the Mooers quadrangle for detailed mapping of its glacial drift and lacustrine and marine formations.

* Glacial and Postglacial History of the Hudson and Champlain Valleys, by CHARLES EMERSON PEET; reprinted (1904), with slight revision, from the Journal of Geology, vol. xii, pp. 415-469, 617-661, July-August and October-November, 1904; with 27 figures in the text (maps, sections, profiles, and views from photographs).

Pleistocene Geology of Mooers Quadrangle, being a portion of Clinton County, including parts of the towns of Mooers, Champlain, Altona, Chazy, Dannemora, and Beekmantown, N. Y., by JAY BACKUS WOODWORTH (Bulletin 83, New York State Museum), June, 1905; pages 60, with 25 plates (maps, and views from photographs), and a folded map of the Glacial geology of Mooers Quadrangle.

Ancient Water Levels of the Champlain and Hudson Valleys, by JAY BACKUS WOODWORTH (Bulletin 84, New York State Museum), July, 1905; pages 65-265, with 28 plates (maps, profiles, and views), 24 figures in the text, and the Glacial map of the Mooers Quadrangle (the same as in the preceding bulletin).

In deference to McGee, Salisbury, and others, who regard the Lafayette and Columbia formations of the Atlantic coastal plain in southern New Jersey, and thence south to the Gulf of Mexico, as of marine deposition, Peet states very fully the arguments that would refer the Late Glacial water body in the Hudson valley to incursion of the sea. This would seem indeed to be the first and most obvious presumption, in view of the fossiliferous marine beds in the Champlain and St. Lawrence valleys at altitudes ranging to a maximum of 560 feet on Mt. Royal, at Montreal, while the divide between lake Champlain and the Hudson river, near Fort Edward, is only 147 feet above the sea level.

But no marine fossils are found in the abundant stratified gravel, sand, and clay deposits of the Hudson valley, which indicates, with the evidences of Quaternary uplift of the southern part of this valley and of the Long Island region and the southern Atlantic coast, that a land barrier on the south held a glacial lake in the Hudson and Champlain valleys, outflowing along the now submarine continuation of the course of the Hudson outside the Narrows. This explanation of the submerged shallow valley and of the modified drift and later stratified beds along the Hudson river, belonging to the time of recession of the continental ice-sheet, I have presented in various publications during the past fourteen years, having in 1892 given the name Hudson-Champlain to this glacial lake.*

In other papers I have argued against the supposed marine origin of the Lafayette and Columbia series, attributing them instead to river deposition on land areas, from erosion of the Appalachian mountain belt at times when that region has undergone epeirogenic uplifts.*

Although a marine or estuarine origin of the Hudson valley deposits is argued by Peet as fully as seems possible, he also gives full consideration to the evidences for the freshwater deposition of these beds, evidently deeming this the more probable view, so that he leaves this question open and undecided.

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* Geol. Soc. of America, Bulletin, vol. iii, pp. 484-487.

* Am. Jour. Sci., third series, vol. xli, pp. 33-52, Jan., 1891. Am. Naturalist, vol. xxviii, pp 979-988, Dec., 1894. Proc., A. A. A. S., vol. xliii, 1894. Compte Rendu du Congrès Géologique International, Zurich. 1894, pp. 238-251. Am Geologist vol. xxv, pp. 313-314, May, 1900.

Woodworth takes more definite ground in support of the explanation of the Hudson beds as sediments of a glacial lake, to which he gives the name Lake Albany; and the glacial lake of the Champlain valley, which he thinks to have been later and distinct, he names Lake Vermont. To the present writer, however, it seems quite certain that the glacially dammed water bodies of these two parts of the Hudson-Champlain valley were continuous at the same levels, changed with the gradual northward uplift of the valley, forming deltas and shore lines which are interrupted by conditions of topography and sedimentation, but which by exact surveys with levelling will be traced continuously from the Hudson valley northward around the marine area of the Champlain,, St. Lawrence, and Ottawa basins, lying at higher altitudes than the marine shores and fossiliferous beds.

By my examination, in 1901, of the lowest part of the water divide between the Hudson and the Champlain, published in the AMERICAN GEOLOGIST for October, 1903, I could find no evidences of outflow there from the glacially ponded waters of the Champlain basin. That divide or lowest place of the watershed, near Fort Edward, seems to me to have been covered by the Hudson-Champlain glacial lake, and by the later glacial Lake St. Lawrence, until the continued departure of the ice-sheet far north allowed the sea to come into the St. Lawrence and Champlain valleys, then filling the southern part of the latter nearly to the hight of this col of its watershed.

The names Lake Albany and Lake Vermont, applied by Woodworth, seem to be synonyms of my previous nomenclature as lakes Hudson-Champlain and St. Lawrence, published in my U. S. Geological Survey monograph of Lake Agassiz and in other papers,* which, however, are not included in the extended bibliography given by Woodworth for this subject, although he cites a large number of my

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* Geol. Soc. of America, vol. iii, pp. 484-7, 1892. Am. Jour. Sci., third series, vol. xlix, pp. 1-18, with map, Jan., 1895. Minnesota Geol. and Nat. Hist. Survey, Twenty-third Annual Report, for 1894 (pub. Feb., 1895), pp. 156-193, with map. U. S. Geol. Survey, Monograph xxv, The Glacial Lake Aggassoz, 1895, pp. 254, 262-264. AM. GEOLOGIST, vol. xxxii, pp. 223--230, Oct., 1903. International Quarterly, vol. xi, pp. 248-265, July, 1905.

earlier glacial papers. Several very noteworthy papers by others, also, as Elias Lewis, Jr.,† and Prof. J. S. Newberry,‡ relating to Long Island and the Hudson valley, are similarly overlooked in his bibliography.

From consideration of the amount and probable rate of the rise of the Champlain and St. Lawrence region from the Late Glacial and Postglacial marine submergence, Woodworth estimates the duration of the Postglacial epoch as somewhere between 20,000 and 100,000 years. The present writer has shown, however, that nearly all the uplifting of the Lake Agassiz area took place probably within so short a time as about one thousand years, during the existence of that lake, since which time the region has been affected only by very slight changes of level. Likewise probably the uprise of the St. Lawrence basin was at first relatively rapid, so that it might all take place within the period of about 7,000 or 6,000 years which is indicated for Postglacial time in that part of the northern United States and Canada by Prof. N. H. Winchell in his studies of the recession of the Falls of St. Anthony, with which my studies of the Niagara falls and gorge well coincide. The former estimate of the period since the Ice age as tens of thousands of years, still advocated by Gilbert and Woodworth, is opposed by a great range of well accordant evidences on the glaciated areas of both North America and Europe.

This Hudson-Champlain area, made classic in glacial geology by the work of C. H. Hitchcock, Baldwin, Baron de Geer, Gilbert, Merrill, Peet, Woodworth, and others, which through the writings of Hitchcock and Dana gave the name Champlain to the closing epoch of the Ice age, deserves yet further work of detailed surveys, with exact levelling for determination of the relations of all its lacustrine and marine shore lines. No other area of our continent promises more important information concerning the Glacial and Recent periods.

It should also be added that the deeply submerged outer fjord of the Hudson, made known with exact soundings and charting by Lindenkohl, is the key to the causes of the

† Pop. Sci. Monthly, vol. x, pp. 434-446, Feb., 1877.
‡ Pop. Sci. Monthly, vol. xiii, pp. 641-660, Oct., 1878.

Glacial period, by its testimony of very great preglacial land elevation, together with the similar evidence given by the submarine continuations of the Congo, the Adour, and other rivers, and by the profound depths of the Scandinavian and Arctic fjords.

THE JURASSIC HORIZON AROUND THE SOUTHERN END OF THE ROCKY MOUNTAINS.

By Charles R. Keyes, Socorro, New Mexico

Soon after passing the Colorado line the Rocky mountains rapidly lose their predominant characteristics and fade out completely into the Mexican tableland. The mountain ranges which succeed to the southward are short, isolated, tilted blocks, that are of a wholly different type from that of the mountainous structures to the northward, and to which they present marked topographic contrasts.

At this southern extremity of the Rockies in northern New Mexico, the general stratigraphy presents some unlooked for phases that are of exceptional interest. Moreover, it is here that the eastern Mississippi valley stratigraphy, with which American workers are most familiar, loses its identity and is replaced by a less known western stratigraphy. The rock-successions of these two provinces have never been satisfactorily or exactly paralleled. Of the many stratigraphic problems that have arisen recently for solution in this region none has possessed greater interest than the questions surrounding the horizon at which the Jurassic system should be represented.

Ever since the time of Jules Marcou's trip, sixty years ago, in connection with the Pacific railroad expedition along the thirty-fifth parallel, when he pronounced the now celebrated Tucumcari section in eastern New Mexico as of Triassic and Jurassic ages, there has been waged one of the bitterest and most useless controversies in the history of American geology. Marcou was well acquainted with Jurassic and Triassic sections of Europe and, as Louis Agassiz has well remarked,* he could hardly be blamed for seeing

* Am. Jour. Sci., (1), vol. xxvii, p. 134, 1859.

a close analogy in the New Mexican sequence. The full force of this position finds another instructive parallel in the so-called Permian question of central Kansas.†

Both of these controversies doubtlessly would have been avoided had all participants relied less on analogy and more upon the actual critical criteria which the formations themselves supply.

Singularly enough, after all these years in which Marcou has stoutly maintained the correctness of his original position, the "Triassic" part of the Tucumcari section appears finally to be determined without much doubt as Triassic in age. It now becomes a question of more than passing interest to inquire anew regarding Marcou's Jurassic beds of the same locality.

According to Marcou's Pyramid mountain section, which is near the Cerro Tucumcari, and which is essentially the same, there were included in his so-called Jurassic sequence (a) about 225 feet of soft, shaly, light-colored sandstones, which Hill has since correlated with the Trinity sands of central Texas, (b) 50 feet of bluish fossiliferous shales, which Hill considers as forming the uppermost poriton of the Washita division of the Comanche series, and from which Marcou collected his few fossils, and (c) 50 feet of massive yellow calcareous sandstone, which has since been found to be the attenuated extension of the Dakota sandstone. Even within the last decade Cummins has gathered all of these beds into a single unit and proposed for them the title of the Tucumcari formation.* All of these formations at Tucumcari appear to form a perfectly conformable succession.

More extended observations have lately shown quite conclusively that marked unconformities actually exist between everyone of the formations mentioned. Regarding them many questions now arise concerning their real significance in the geological history of the region.

The remnant of the Dakota sandstone (c) which is found in the Tucumcari section is now known to form the base of the Mid-Cretaceous (Upper Cretaceous of Meek

† Journal of Geology, vol. vii, pp. 221-241, 1899.
* Texas Geol. Sur., Third Ann. Rept., p. 201, 1892.

and Hayden). It rests unconformably on all older formations, from the Mid-Carboniferous limestones to the Comanche series.

The shale (b) beneath the massive sandstone at the top of the Tucumcari section, has been correlated with the topmost portion of the Washita division of the early Cretaceous as represented farther to the eastward in Texas. The lower members of the early Cretaceous successively thin out to the north and west from the central part of that state and each overlaps the next below.

The next formation below (a), which rests unconformably upon the Triassic Red Beds and which has been paralleled with the Trinity sands of central Texas appears to be a formation with as yet no tangibly determinable relationships. It may be the basal member of the early Cretaceous section which is so well developed farther to the eastward, and this has been the view advanced by Hill and other workers in the Texas field. Or, it may be a littoral deposit that followed up an advancing shore; and thus it may have an age in its different parts extending throughout the Comanche period. However, this phase of the subject receives full discussion elsewhere.

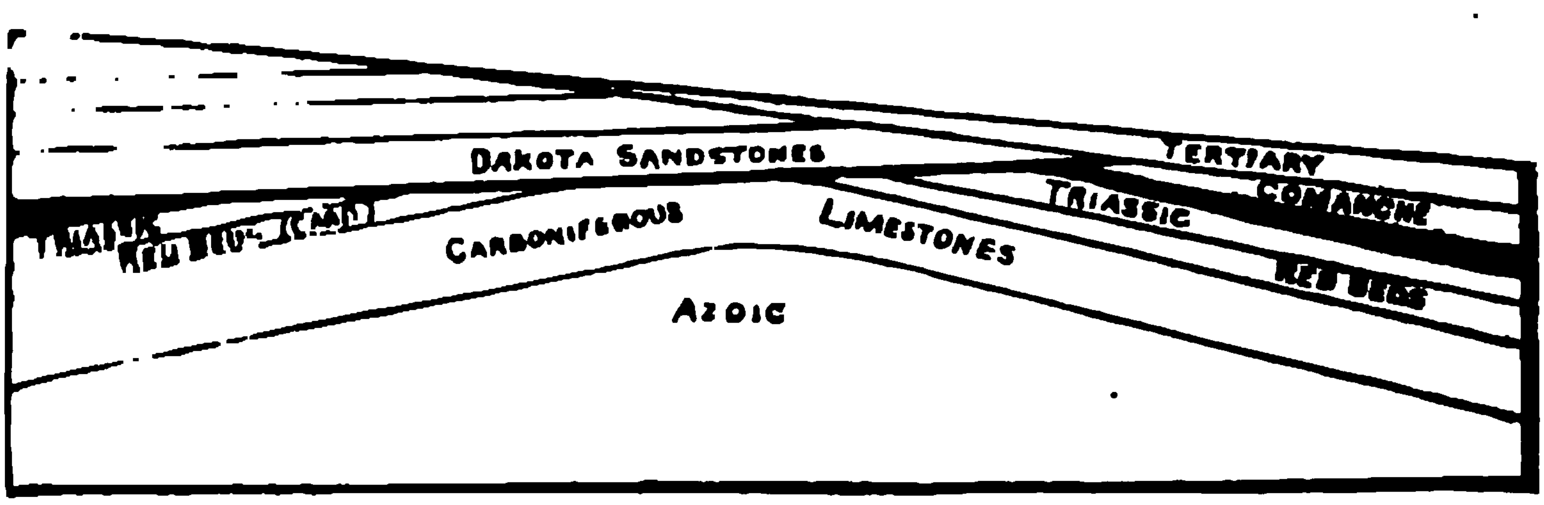
This so-called Trinity sandstone stands apart from all else. It has no direct genetic relationships with the formations either above or below. The unconformable relations that it bears both to the superior strata and to the inferior rocks clearly indicates the lapse of a considerable time interval at least at the base. There is then in this sandstone an important geological formation about which little is yet definitely known regarding its geological relationships; and to the westward at the same horizon an important erosion interval is represented. The equivalents of these in the sediments of other localities, as well as the space they represent in the general geological column have become topics of some speculation.

White, who was long the best American authority on the Cretaceous rocks, considered the Trinity sands, or Dinosaur beds, as reaching down into the Jurassic period. Marcou regarded the Jurassic as partially represented by this formation. Most writers have disputed the existence

of any Jurassic beds in this part of the continent. Their evidence has been even less conclusive than that presented by the pioneer geologist just mentioned. It is now known that Marcou and his critics were not discussing exactly the same thing.

Independent of whatever may have been concluded in the past regarding the presence or absence of Jurassic deposits in the Tucumcari section it is certain that there exists at the horizon where the Jurassic system is naturally located in the general geological column, a stratigraphic gap and a formation about which there is much to learn before their real significance is understood. It may be that after all Marcou's surmise was right and that the Jurassic system finds representation in the Cerro Tucumcari, just as it now appears that his shrewd guess regarding the Triassic eventually proved to be correct.

In this connection it is of interest to note that in western New Mexico, in the Zuni region, Dutton has regarded the great sequence of sandstones which he called the Zuni series, and which is upwards of 1,200 feet thick, as very likely of Jurassic age. He correlated this series with the extensixe deposits of so-called Jurassic age in Arizona, Utah and southwestern Colorado. The Zuni series for the present is here still associated with the Triassic system. Its stratigraphic relationships, especially with the Dakota sandstones, and the position in the Tucumcari region are indicated in the section subjoined (Fig. ..).



THE JURASSIC HORIZON IN THE SOUTHERN ROCKY MOUNTAINS.

The horizon represented by the heavy line is worthy of much attention. Its stratigraphic horizon is that of the Jurassic system of the general geological section.

INSTITUTO GEOLOGICA DE MEXICO.

EL INSTITUTO GEOLOGICA DE MEXICO.

By F. N. Guild, Tuscon, Ariz.

PLATE XV.

Since the International Congress of Geologists is to convene in the city of Mexico during the coming summer of 1906, it may be interesting to the readers of the AMERICAN GEOLOGIST and especially to those who expect to attend the congress, to learn something of the work of the Institute in Mexico which corresponds to our national geological survey. Such a description seems especially opportune at the present time when the Institute has taken up its quarters in an excellent new building expressly designed for its purposes, and is now busily engaged in sending invitations to all parts of the world and making other preparations for the congress which is to be held within its walls.

The first step which led to definite results in the formation of a geological survey in Mexico was made in 1886 and through the efforts of Antonio del Castillo, then professor of mineralogy and geology in the School of Mines, an authorization was obtained two years later for the formation of a Comision Geologica de México. The first publication issued in 1895 appeared under the title of Boletin de la Comision Geologica de México. Later, however, the name was changed to Instituto Geologico National de México and the publications appeared under that name. Castillo, who may be considered as the founder of the Institute, was chosen director which position he held until his death in 1895. One of the first objects of the Institute seems to have been the preparation of sketches (bosquejos) on the general geology of the country. These appear in bulletins No. 4, 5, and 6. They are accounts of scientific expeditions by various members of the staff into different parts of the republic.

The Institute was first housed in the School of Mines building, later however, removed to temporary quarters in the Calle de Paseo Nuevo Num. 2, and finally into its present building on 5a Calle del Ciprés. It is equipped with excellent chemical laboratories for the analysis of rocks and minerals, museums for geological and mineralogical collections, drafting rooms, libraries, laboratories for microscopic

investigation, and all necessary appliances for geologic research. The museum is especially well equipped with a large collection of nicely trimmed rocks and thin sections corresponding. Possibly there is no better place than Mexico for the study of variations in rhyolitic and andesitic outflows, and the Instituto Geologico keeps its doors open to scientists who desire to study there. The staff of the Institute at present consists of José G. Aguilera, appointed director on the death of Castillo, Ezequiel Ordonez, subdirector and petrographer, Emilio Böse, Carlos Burckhardt, Juan D. Villarello, E. Angermann, T. Flores, R. Robles, S. Truax, and A. Villafana, geologists, R. Santillan, secretary, F. Roel, and V. de Vigier, chemists.

The Institute has an interesting and in some respects unique field for investigation. The larger portion of the sedimentaries and older crystalline rocks in Mexico are covered by great masses of recent products of volcanic activity such as ashes, andesitic and basaltic outflows. The Institute has a very complete collection of these rocks which have quite thoroughly been worked out from a petrographical standpoint and presented to the public through its excellent bulletins. Its investigators plan in the near future to discuss more completely the chemical relations of the outflows and doubtless valuable additions will be made to our knowledge of the differentiation of volcanic magmas. Volcanic craters are found everywhere, some in the state of activity (Colima) others possessing but faint traces of their former power (Popocatepetl). Even within less than two hours ride from the city of Mexico groups of volcanoes may be studied where crater cones rise but a few hundred feet above the level valley of Mexico (Sierra de Catarina.) These present variations from pure cinder cones (Las Calderas) to cones from the crater of which more liquid material has escaped (Cerro de Ixtapalapa). Thus a more ideal spot for the investigation of at least one phase of geology could hardly be imagined.

Following is a list of the publications of the Institute:

Num. 1.—Fauna Fósil de la Sierra de Catorce, por A. del Castillo y J. G. Aguilera.—1895.—56 pp., 21 lám.

Num. 2.—Las Rocas Eruptivas del S. O. de la Cuenca de México, por E. Ordónez.—1895.—46 pp., 1 lám.

Num. 3.—La Geografia Fisica y la Geologia de la Peninsula de Yucatán, por C. Sapper.—1896.—58 pp., 6 lám.

Nums. 4, 5 y 6.—Bosquejo Geológico de México.—1897.—272 pp., 5 lám.

Nums. 7, 8 y 9.—El Mineral de Pachuca.—1897.—184 pp., 14 lám.

Num. 10.—Bibliografia Geológica y Minera de la Republica Mexicana por R. Aguilar y Santillán.—1898.—158 pp.

Num. 11.—Catálogos sistemático y geográfico de las especies mineralógicas de la Republica Mexicana, por José G. Aguilera.—1898.—158 pp.

Num. 12.—El Real del Monte, por E. Ordónez y M. Rangel.—1899.—108 pp., 26 lám.

Num. 13.—Geologia de los alrededores de Orizaba, con un perfil de la vertiente oriental de la Mesa Central de México, por Emilio Böse.—1899.—78 pp., 3 lám.

Num. 14.—Las Rhyolitas de México (Primera parte), por E. Ordóñez.—190.—78 pp., 6 lám.

Num. 15.—Las Rhyolitas de México (Segunda parte), por E. Ordónez.—1901.—78 pp., 6 lám.

Numero 16.—Los Criaderos de fierro del Cerro del Mercado en Durango, por M. Rangel, y de la Hacienda de Vaquerias, Estado de Hidalgo, por J. D. Villarello y E. Böse.—1902.—144 pp., 5 lám.

Numero 17.—Bibliografia Geológica y Minera de la Republica Mexicana por R. Aguilar y Santillán.—1904. [*En prensa.*]

PARERGONES.

Tomo I. No. 1.—Los temblores de Zanatepec, Oaxaca.—Estado actual del Volcán de Tacaná, Chiapas, por Emilio Böse.—1903. 25 pp., 4 lám.

No. 2.—Fisiografia, Geologia é Hidrologia de los alrededores de la Paz, Baja California, por E. Angermann.—El área cubierta por la ceniza del Volcán de Santa Maria, Octubre de 1902, por Emilio Böse.—1904. 26 pp., 3 lám.

No. 3.—El Mineral de Angangueo, Michoacán, por E. Ordónez.—Análisis de una muestra de granate del Mineral de Pihuamo, Jalisco, por J. D. Villarello.—Apuntes sobre el Paleozoico en Sonora, por E. Angermann.—1904. 34 pp., 2 lám.

No. 4.—Estudio de la teoria quimica propuesta por el Sr. Andrés Almaraz para explicar la formación del petróleo de Aragón, México, D. F., por J. D. Villarello.—El fierro meteórico de Bacubirito, Sinaloa, por E. Angermann.—Las aguas subterráneas de Amozoc, Puebla, por E. Ordónez.—1904.—24 pp., 1 lámina.

No. 5.—Informe sobre el temblor del 16 de Enero de 1902 en el Estado de Guerrero, por los Dres. E. Böse y E. Angermann.—Estudio de una muestra de mineral asbestiforme procedente del Rancho del Ahuacatillo, Distrito de Zinapécuaro, E. de Michoacán, por el Ing. J. D. Villarello.—1904.—26 pp.

No. 6.—Estudio de la hidrologia subterránea de la región de Cadereyta Méndez, E. de Querétaro; por el Ing. J. D. Villarello.—1904. —58 pp., 2 lám.

No. 7.—Estudio de una muestra de grafita de Ejutla, Estado de Oaxaca, por el Ing. J. D. Villarello.—Análisis de las cenizas del volcán de Santa Maria, Guatemala, yor el Ing. E. Ordóñez.—1904.—26 pp.

No. 8.—Hidrologia subterránea de los alrededores de Querétaro, por el Ing. J. D. Villarello.—1905.—56 pp., 3 láminas y 2 figuras.

City of Mexico, Aug. 25, 1905.

SERPENTINES IN THE NEIGHBORHOOD OF PHILADELPHIA.

ANNA I. JONAS, Bryn Mawr, Pa.

The object of this paper is to give a brief review of the occurrence and origin of the known serpentines, and to describe in particular, the serpentine dykes in the neighborhood of Philadelphia, Penna.

It is generally conceded that serpentine, wherever occurring as a mineral or a rock, is a secondary product formed in the zone of katamorphism and that it is developed by the alteration of non-aluminous, ferro-magnesian silicates; olivine, the pyroxenes, anthophyllite, tremolite and actinolite. In a less number of cases serpentine has been derived from a limestone.

An entire rock mass may be composed exclusively of serpentine, or the rock may contain remains of the original minerals from which the serpentine was derived. The physical characters of the rock serpentine are therefore somewhat modified by the presence of associated minerals. In color serpentine has a wide range through all shades of green, brown and reddish brown. Its texture depends largely on the mineral from which it was derived; serpentine formed by the hydration of olivine is massive; that variety formed by the alteration of an amphibole is usually fibrous. That variety which results from the alteration of pryoxene may be described as massive.

Since serpentine, a katamorphic product, is not easily weathered, it usually forms a ridge scantily covered with a sterile soil composed of silica, magnesia and stained with iron oxide.

Distribution.—Serpentine has a wide distribution through the British Isles and Europe, and has been described from several localities in Asia and Africa. The serpentines of England, Wales and Scotland have been traced to olivine rocks and are usually associated with masses of gabbro or dioryte. The serpentines of Europe, for the most part, occur in belts of igneous rocks and crystalline schists and gneisses, and are largely derived from peridotytes, pyroxenytes or gabbros. Serpentinised marble is re-reported from the Passauer gneiss district of central Europe, from the upper Reno valley of Italy and from the Knopia district of Finland, and serpentine is associated with calcareous schists on Corsica and at Antioch, Asia.

In America serpentine is found throughout the belt of crystalline formations which extends from Maine to Alabama and forms the floor of the Piedmont plateau.

Maine.—*In Maine, serpentine has been reported by Mr. George P. Merrill at the northern end of Deer Isle in Penobscot bay. He describes it as a very dark green variety mottled by diallage crystals.

Vermont.—There are many localities of serpentine in the state of Vermont† on the boundary between Dover and Newfane counties, at Windham; in the hills of the northwestern part of Chester extending to Ludlow and Cavendish; at Plymouth, Roxbury, Westfield and Troy. The serpentine is associated with steatite and occurs both in mica schists and gneisses. It is placed among the stratified rocks because it occurs as thick beds in foliated rocks and does not cut them. This could be accounted for on the supposition that the serpentine was an intrusive which had been folded along with the rock into which it was intruded. The steep slopes of Belvidere‡ mountain are composed of amphibolyte. In it the hornblende has been largely altered to fibrous serpentine.

Massachusetts.—In the Holyoke folio Emerson discusses the serpentine which extends from Holyoke, Massachusetts, south into Connecticut. The Chester amphibolyte

*G. P. Merrill, "Stones for Building and Decoration," p. 60.

† Geology of Vermon 1861, vol. 1, p. 544.

‡ Science, vol. xxi, No. 533, Mar. 17, 1905 (review). "The Serpentine and Associated Minerals of Belvidere mountain, Vermont," by V. F. Marsters.

is described as a "dark, flaggy hornblende schist," in part replaced by serpentine and emery. In an earlier publication it was described as an altered eruptive, but in this folio Emerson calls it an altered sediment, probably a dolomyte and of Lower Silurian age, lying between the Rowe and Savoy schists, both of which are sericite schists. Emerson decided that the Chester amphibolyte is a sediment because in the sedimentary series of Connecticut, Massachusetts and Vermont there are beds of dolomyte which pass into enstatite limestones and amphibolytes. Not only is emery found in limestones but the amphibolytes of the above mentioned series are derived from limestones. The Pelham gneiss* is exposed in long, narrow strips, extending north and south and lying to the east of the Connecticut river in Pelham and Shuttesbury. In this gneiss are dykes of a bronzite-olivine rock partially altered to serpentine.

In this monograph Emerson mentions the occurrence of serpentine in the Chester amphibolyte. It enters Massachusetts from Vermont and extends southwest through Rowe, Hampshire, Hampden, Blauford, Granville and Russel counties and dips below the sands of the Westfield plain and does not reappear.

New York.—In 1887 Dr. Williams published a paper on the serpentine† in the Onondaga salt group at Syracuse. The exposure was situated on James street but for many years has been inaccessible. It was noted in 1837 and reported to Vaunuxem, the state geologist, who regarded it as an aqueous deposit. Dr. Williams claims for it an igneous origin;‡ in 1890 he published some additional proof for his view.

§ In Essex county at Port Henry and Moriah, there is serpentine derived from an altered dolomyte and pyroxene limestone. A similar rock is found in Warren county. Serpentine is associated with limestone in St. Lawrence county, New York.

* Serpentine from the vicinity of New York City is found at Rye and New Rochelle in West Chester county,

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* Monograph xxix of U. S. G. S. by B. K. Emerson.
† Am. Jour. Sci., 3rd Ser., vol. 34, p. 137, "The Serpentine of Syracuse, New York," by G. H. Williams.
‡ Bull. Geol. Soc. Am., vol. i, pp. 595-600.
§ G. P. Merrill, "Stones for Building and Decoration."

at Staten Island in New York City and at Castle Point, Hoboken, N. J.

† Mr. Newland has described all these serpentines and believes that they are derived from pyroxenytes and peridotytes. He objects to J. D. Dana's view that the New Rochelle serpentine is derived from a limestone containing intruded silicates. ‡ Mr. F. J. H. Merrill says that the serpentine of New Rochelle, is derived chiefly from amphibole and bronzite which are almost completely serpentinised. The rocks from which serpentine was derived were amphibolytes and other magnesian silicate rocks intruded into Ordovician schists.* Julien describes in detail, amphibole schists, (pyroxene schists), dioryte schists and gneisses throughout Manhattan island. The one area of serpentine that is of importance occupies a long belt between West Fifty-fourth and Sixty-third streets from Tenth avenue to the Hudson river. It represents a further alteration product of the hornblende schists; both are alterations of basic igneous intrusions.

New Jersey.—A different origin has been proposed for the deposits at Montville, N. J.† Mr. G. P. Merrill considers the serpentine to be the result of the alteration of a non-aluminous pyroxene enclosed in a magnesian limestone. At Mendham in the same belt of limestone there is found serpentine with a similar origin.

Pennsylvania.—In Pennsylvania serpentine is found in Northampton, Bucks, Montgomery, Delaware, Chester and Lancaster counties, forming in general, lenticular areas with a strike southwest and northeast. *There is an area north of Easton in Northampton county and small areas along the Lehigh river. The Easton area occurs on the southeastern slope of Chestnut hill. The hill is composed of pre-Cambrian gneisses interstratified with beds of cal-

* New York Acad. Trans., vol. i, p. 58.

† School of Mines Quarterly, Apr. 1901, p. 307, July 1901, p. 399, article by D. H NEWLAND.

‡ Appendix A. The Geology of the Crystalline Rocks of Southeastern New York, by F J. MERRILL, Reprinted rfom the New York State Museum Report, 1896.

* Bull., of Geo. Soc. Am., vol. 12, pp. 421-494. Genesis of the Amphibole Schists and Serpentines of Manhattan Island, N. Y., by ALEXIS A. JULIEN.

† Proceed. U. S. Nat. Mus., vol. xii.

* Reprint from Annals N. Y. Acad. Sci., vol. xiii., No. 6 .pp. 419-430. Jan. 14, 1901, by F. B PECK.

cite and dolomite which furnish the main source of the serpentine. In Bucks county there are two small serpentine areas on the west bank of Neshaminy creek, which are products of the alteration of basic intrusives. The northern is associated with gabbro and the southern area is intrusive in the Wissahickon mica-gneiss.

*The serpentines of the Philadelphia belt of crystalline rocks occur in a series of dykes which extend through Montgomery county into Delaware and Chester counties; they will be described in detail later.

The so-called state line serpentines are a continuation of one of these dykes. They extend for sixteen miles along the boundary between Pennsylvania and Maryland, beginning in Chester county, at Little Elk creek, and extending into Lancaster county and southwest into Cecil county, Maryland.† These like the other serpentines are altered eruptives.‡ They are associated with pyroxenytes and peridotytes and they represent the alteration product of these rocks. From Cecil county westward through Harford* † and Baltimore counties, southwest along the base of Parrs ridge, across Howard and Montgomery counties to the Potomac. They are secondary products of both pyroxenytes and peridotytes.

Delaware.—From the northeast corner of Delaware, extending southwest into Maryland is a belt of gabbro and associated rock types.‡ At Chestnut Hill and Iron Hill the peridotyte is serpentinised. In Delaware there is one other serpentine area. It lies in northern New Castle county east of Red Clay creek. It is intrusive in the mica-gneiss and with it as is frequently the case, are associated pegmatytes which may represent the most acid phase of the magma of which the mother rock of serpentine is the most basic.

Virginia.—In Virginia W. B. Rogers has described serpentine from the soapstone rocks of Nelson* and Amherst counties.

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* Bull. 13, Geo. Soc. Amer.
† F D. Chester, Penna. Geol. Surv., Ann. Rept., 1887, pp. 93-105.
‡ Maryland Geol. Surv., Rept. of Cecil Co., F. Bascom.
* Am. Geol., July, 1890. The Non-Feldspathic Intrusive rocks of Maryland, by G. H. Williams
† These serpentines have been described by Dr. A. Johannsen in an elaborate paper which has not yet been published.
‡ Bull. 59, U. S. G. S., 1896, by Frederick D. Chester

North Carolina.—† The peridotyte serpentine belt of North Carolina is scattered over an area forty miles wide. For the most part the peridotyte is fresh and its olivine shows but slight alteration to serpentine. South of Waynesville there is only one small area of massive serpentine but to the north in Buncombe, Madison and Yancey counties there is much typical massive serpentine.

‡ *Georgia*—In Harris county, western Georgia, Clements reports serpentine. It is derived from the peridotyte of the belt which extends into Georgia from Carolina and bears corundum.§ This belt extends westward into ‖ eastern Alabama and there contains serpentine associated with steatite. This is the most southerly extension of the belt of crystallines with which serpentine is associated and which extends throughout the Atlantic states.

There are scattered areas of serpentine in Texas, Minnesota and Colorado. In the Cascade and Sierra Nevada mountains of Washington and Oregon and in the coast range of California, in the Sacramento valley and on the San Franciscan peninsula, serpentine has been described and its origin traced to pyroxenytes and peridotytes.

The Serpentines of the Philadelphia Belt.—The Piedmont belt of the eastern United States lies between the Appalachian province to the west and the coastal plain region to the east. It extends from Maine southwest to middle Alabama. Its surface is rolling with flat topped hills separated by deep cut valleys. On these hills is seen the remnant of the Jurassic peneplain; after this peneplain had received its load of Cretaceous sediments and had been raised above sea level, streams began to cut into the Cretaceous sediments. They wore through them and cut gorges into the crystalline rocks of the Piedmont.

The rocks across which the streams flow are gneisses, quartzyte, marble and schists, closely folded and faulted. They are cut by eruptives which range widely in composition. There are two belts of crystallines separated by a cover of Triassic sandstone.

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* Geology of the Virginias, 1884, W. B. Rogers, p. 296-297.
† Geol. Surv. of N. Car., 1896, Bull. 11, by Lewis.
‡ Bull. 5, Alabama Surv.
§ Bull. 2, Geol. Surv. Georgia, on Corundum Deposits.
‖ Bull. 5, Alabama Surv., by Alfred Brooks.

In the southeastern belt, the oldest rock is the Baltimore gneiss of pre-Cambrian age. It is composed of light bands of quartz and feldspar alternating with dark hornblendic layers, closely folded and contorted. This rock together with gabbro forms Buckridge and strikes northeast and southwest, separating the Cambro-Silurian series of quartzyte, limestone and mica-schist from the Wissahickon mica-gneiss to the southeast. Unconformably overlying the Baltimore gneiss is the Chickies quartzyte, a thinly bedded crystalline rock full of sericite, which gives it a buff to green color and a schistose character. This resistant rock forms the ridge of the north Chester valley hills. To the south of these hills is the limestone of the Chester valley. It is a magnesian limestone of Cambro-Silurian age and it grades upward into the Hudson River mica-schist, which caps the south Chester valley hills. The mica-schist is a schistose rock composed of mica and quartz; the quartz is present in lenses about which the mica is bent.

The age of the Wissahickon mica-gneiss has not yet been fully worked out. The rock is silvery gray in color, with alternating schistose and gneissic bands. Abundant mica shows on the cleavage planes and quartz and feldspar on planes at right angles to the cleavage.

The Triassic cover of red sandstone and shale still remains over a portion of the Piedmont plateau. Contemporaneous with the deposition of the Triassic beds was a flow of basalt and an intrusion of diabase extending from Connecticut to Virginia. In Pennsylvania this resulted in a series of diabase dykes which extend southwest through the plateau.

The older igneous rocks are more abundant in the region. There was a period of post-Ordovician and pre-Triassic activity which assisted the forces of regional metamorphism in altering the sedimentary Palæozoic and pre-Palæozoic rocks. The igneous material is granite and gabbroitic, the main mass is gabbro which, in the vicinity of Philadelphia is intruded into the Baltimore gneiss and mica-gneiss. The rock is either an augite, or hypersthene-gabbro penetrated by dykes of peridotytes or pyroxenytes.—It is

these ultra basic rocks which furnish the original material from which the serpentine is derived.

* The serpentines of the Philadelphia belt occur as dykes, intrusive in the mica-gneiss and Baltimore gneiss and strike southwest and northeast.

They may be grouped into four dykes, each composed of a series of non-continuous outcrops extending southwest from near the Schuylkill. They form prominent ridges which are covered but scantily with soil and which are characterised often by a growth of cedar trees.

The southeast dyke is intrusive in the Wissahickon mica-gneiss and extends from Chestnut Hill southwest to one mile east of Bryn Mawr station. The dyke as exposed at Lafayette is typically a grayish green soapstone. At Black Rock quarry the serpentine is a grayish green rock mottled with large dark green olivine crystals; specimens have been found in which are large cross twins of serpentinised olivine. Under the microscope the mass of the rock is steatite, appearing with crossed nicols as brilliantly polarising scales. The steatite is considered to be an alteration product both of an original pryoxene and of the serpentine which it penetrates. The olivine present is altered only along the periphery and cracks and cores of it still remain. In addition the rock contains very abundant calcite and magnetite.

The rock is an altered peridotyte whose original constituents are olivine and pyroxene which have altered to serpentinised talc and the by-products which accompany serpentinisation. Along the contact of the dyke with the mica-gneiss there has been formed chlorite-schist, a green schistose rock composed of chlorite with needles of hornblende.

The second dyke lies to the northwest of the first and is intrusive in the Wissahickon mica-gneiss close to the boundary between it and the Baltimore gneiss. The dyke shows an exposure east of the Schuylkill. From Lafayette on the west side of the river it extends southwest with almost continuous outcrops to Delaware county where it widens out considerably. The rock is very similar to that

of the dyke just described. In microscopic section it shows serpentine altered from olivine and secondary tremolite and anthophyllite partially altered to serpentine. Enstatite may be present fresh or unaltered. Talc, calcite and magnetite occur in abundance. From the fresh structure seen under the microscope and the presence of olivine in various stages of alteration to serpentine the original rock is decided to be a peridotyte.

The third dyke shows one exposure in Montgomery county. On the edge of the gabbro area, along Arrowmink creek. A second exposure known as Castle Rock, is situated in Delaware county near Edgemont. It is an example of serpentine resulting from the alteration of a pyroxenyte. The rock is medium grained and dark green, composed of fibrous tremolite, augite, enstatite and talc. The original pyroxenes are augite and enstatite while tremolite is a necessary product. All three minerals show alteration to talc which pierces them in all directions. This description applies to a specimen obtained from the center of the mass; in an outlying portion the rock is almost completely serpentinised and is a dense, massive, green serpentine of uniform character. The rectangular cleavage of augite outlined by iron oxide can be seen in the serpentine.

The outcrop of the fourth dyke extends sporadically from Guelph Mills, in Montgomery county southwest into Chester county. Three-fourths of a mile south of Paoli the dyke gives rise to a barren ridge which is a distinct topographic feature for ten miles to the southeast. The rock south of Paoli is a light yellowish green serpentine very massive in character and yet under the microscope showing evidence of alteration from olivine and in a small part from a pyroxene.

A study of the field relations and microscopic sections of the serpentines of the Philadelphia belt shows that they are secondary to pyroxenytes and peridotytes which they have in a large measure replaced. Such an origin has been ascribed to the greater part of the serpentines of the world and it is only in a few cases that they have been regarded as secondary products of sedimentary rocks.

AN EXPLANATION OF THE PHENOMENA SEEN IN THE BECKE METHOD OF DETERMINING INDEX OF REFRACTION.*

By W. O. HOTCHKISS, Madison, Wis.

In the identification of minerals in rock sections the method of procedure is always the determination of the fixed physical properties. Among these constants, the ones which are ordinarily employed on account of their easy determination are the index of refraction, birefringence, positive or negative character, orientation of the plane of the optic axes, and angle of the optic axes. Cleavage and extinction angles are also useful when the orientation of the section can be ascertained with any degree of certainty. Among these properties the refractive index and the birefringence are probably known for the widest range of minerals and are therefore most useful. The latter is readily determined by the method described by L. V. Pirsson and H. H. Robinson.† The former is measured by the method of Count von Chaulnes (see Rosenbusch-Iddings for description of method) and by the Becke method. The first method gives the numerical index but is clumsy and inaccurate; the latter merely indicates whether the index is higher or lower than that of the contiguous medium, but it is easily applied and is so delicate that differences in refractive index of .001 have been observed by the originator of the method. The extreme usefulness of the Becke method led the writer to endeavor to find a more detailed explanation of the phenomena observed. The construction, given below, it is believed, will satisfactorily explain all the phenomena.

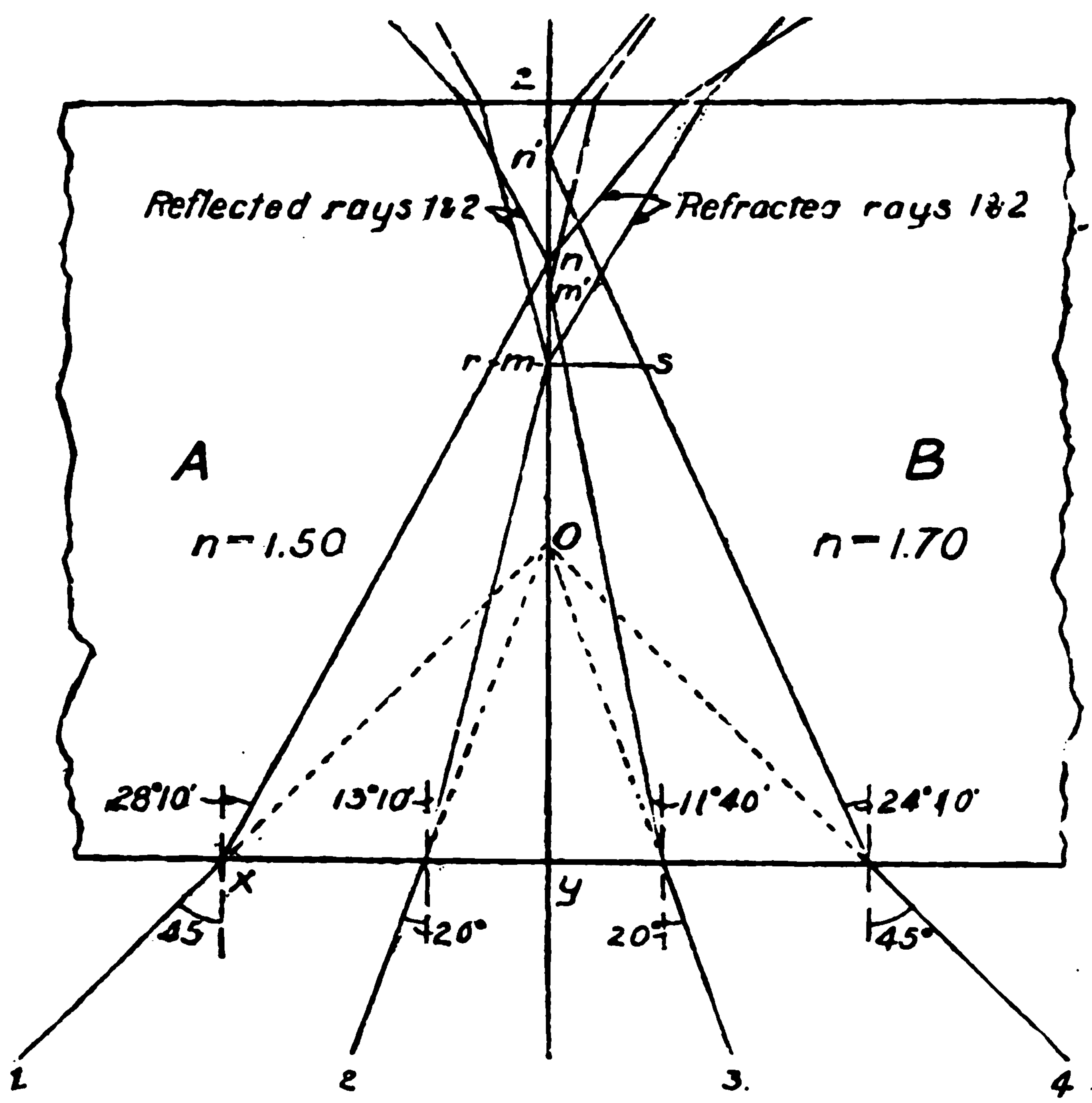
Let us assume A B, in fig. 1, to be a cross-section of two minerals with indices of 1.50 and 1.70 respectively, whose plane of contact is represented by the line C D and is perpendicular to the page. Then if the section be in a microscope arranged to give convergent polarized light the convergent rays will come from below and the objective lie above the cross-section as shown. Ray 1 is refracted so as

*Ueber die Bestimmbarkeit der Gesteinsgemengtheile, besonders der plagioklase auf Grund ihres Lichtbrechungsvermögens. Sitzungsb. k. Akad. Wiss. Wien, Mathem—naturw. Classe. Bd. CII. Abth. I. Juli, 1893, pp. 358-376. See also Rosenbusch-Iddings, appendix.

† A. J. S., 4th Ser., vol. x, pp. 260-265, 1900.

to meet the plane between the two media at the point n, at a distance above the point x of 1.87 times the length x-y. Ray 2 meets it at m, a distance equal to 1.56 times x-y. Rays 3 and 4, since B has higher index, are refracted to meet the plane at points m′ and n′, higher than the similar rays in A, or at distances above y of 1.76 and 2.18 times x-y, respectively.

At the surface of contact between A and B the critical angle is 62° 10′ and so all rays incident on y-z from B at an angle greater than 62° 10′ are totally reflected back into B.



On the other hand, a portion of the light from A incident upon y-z is refracted into B. The ratio between the amount reflected and the amount refracted depends upon several factors. In proportion as the contact surfaces of A and B are highly polished, more light is reflected and less refracted; as the angle of incidence increases more light is reflected and less refracted; and as the difference in the in-

dices increases the amount of light reflected becomes greater. Since the contact surface of minerals in rocks is seldom smooth the tendency is for a large part of the light from A to be refracted into B, and the condition obtains as shown in the figure,—that for a certain vertical distance along the contact, approximately equal to mn′, nearly all the light will be on side of the mineral having the higher index. If the objective of our microscope is focused within this vertical distance a band of light will be seen, if it is raised the band will be seen to broaden, as is evident from the directions of the refracted and totally reflected rays. If, on the other hand, the objective is lowered, the band becomes narrower and finally is brighter on the side of the mineral of lower index. This is explained by the fact that the light in A, which is approximately the same in amount as that in B at this distance above the base of the section, is concentrated in a band of width mr which is shorter than ms and will therefore show greater intensity. As the objective is lowered, the bright band in A and the less bright one in B broaden out.

If rays from B are incident upon y-z at an angle less than the critical angle (62° 10′ in the case illustrated), they will not be totally reflected but will partly pass through into A. If there is sufficient light thus refracted a bright band will be seen in A as well as in B when the objective is raised. It is important therefore to diaphragm the light entering the condensing system to such an extent that all the light from B is totally reflected at the contact surface. This increases the relative brightness of the band seen in B.

Computations of the different values of the distances from y to m and n were made for other indices besides the two figured. The angles of incidence of the four converging rays were taken as 45° and 20° as in the figure and the distance from x to y was taken as unity.

It is evident from this table that the distance from n to n′ (see fig. 1) is quite within the range of observable quantities even for slight differences in index of refraction. The lengths of yn and ym for indices of 1.54 and 1.56 were com-

Index	Angles of refraction for Incidence of 45°	20°	y n	y m	Diff. (n-m)
1.50	28° 10′	13° 10′	1.87	1.56	.31
1.54	27° 20′	12° 50′	1.93	1.60	.33
1.56	27° 0′	12° 40′	1.96	1.62	.34
1.60	26° 10′	12° 20′	2.04	1.66	.38
1.70	24° 40′	11° 40′	2.18	1.76	.42
2.00	20° 40′	9° 50′	2.65	2.10	.55

puted with this in mind. In these yn for 1.54 is .03 less than for 1.56. If these figures are reduced so as to be comparable with the thickness of microscope sections, the difference in a section of .030 mm. thick would be about .0005 mm.—a magnitude which, though hard to measure accurately, is easily observed.

The difference between ym and yn bears a fairly constant ratio to yn for the common range of indices—being about one-sixth. This in a slide .030 mm. thick would be .005 if yn be taken as the thickness of the plate. This magnitude (.005) is about the average change in focus necessary to cause the bright band to shift from one side of the contact to the other. Within this distance the light coming from the side having the greater index is totally reflected, while from the other side the larger part is refracted at the contact. Therefore the focus must be changed through a distance of this order of magnitude in order to show the band on opposite sides.

The application of this method of determining relative index of refraction is very simple. If the instrument used is not provided with a diaphragm below the condensing lense, the hand may be used to shade the mirror, thus cutting off part of the light. As a matter of experience it is found that the hand is used quite as frequently as the diaphragm by one accustomed to the method. The fact that as the objective is raised the light band goes to the side of the higher index and vice versa provides a simple memory rule—focus high, band on side of higher index; focus low, band on side of lower index.

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EDITORIAL COMMENT.

CONSOLIDATION OF THE GEOLOGIST WITH ECONOMIC GEOLOGY.

It is announced among the advertisements of this issue of the AMERICAN GEOLOGIST that the GEOLOGIST will be consolidated, after January 1, 1906, with the new journal, ECONOMIC GEOLOGY and the facts of interest to subscribers are there treated. It remains to make further comment from the editor's standpoint.

When the AMERICAN GEOLOGIST was started(1888) there was no distinctively geological journal in America, and the Geological Society of America had not yet been organized. The United States Geological Survey was in a transitional stage. Geology in America was represented in the International Congress of Geologists by a number of delegates from the American Association for the Advancement of Science. If American geology found any means of expressing itself its voice was likely to be muffled by passing through non-sympathetic agencies.

These things have changed. The science is not only more independent and urgent in the presentation of its interests, but has come into recognition more and more as an element in modern civilization which needs to be cared for, as well as a producer and safe-guard of a large share of the wealth and comfort of the nation.

The aspect of American geology, as expressed in the purposes and publications of the various geological surveys, has changed within the past 18 years. Time was when the director of the United States Geological Survey, in its extension over the older states of the Union, defined the sphere of that survey to be the study and publication of paleontological and structural problems, united with the mapping of the nation's domain, leaving for the various state surveys the investigation of economic subjects. Within a few years, however, the economic features of the United States Survey have expanded enormously. The efficiency of the survey and the judiciousness of its expenditures have won from Congress larger and larger sums of money, and have led to the extension of its activities over wider and wider fields of

research. The various state surveys have also devoted their energies more fully to the question—how to make the survey immediately useful. Pure science, excepting so far as it is prompted and promoted by the search for the useful, has been less in evidence in the state reports.

In volume 14 of the GEOLOGIST (p. 186) in an editorial are the following words:

"It is not too much to say that to the miner, and hence to the mining industry, geology must look for most of its future progress, at least in the United States. In Canada the economic side of geology has always been put to the front, and systematic geology has been comparatively neglected. The reverse has been the case in the United States. The example of New York State, which has entirely neglected, officially, its economic resources, and has spent much upon the technical and paleontologic aspects of geological science,* has been followed by too many of the state surveys, and too closely by the United States Survey. Economic geology has made headway in spite of this indifference. Speculative and technical geology has had the field for many years, but it becomes more and more apparent that room must be made for an extension of that phase of the science which directly concerns the greatest number of people."

The present witnesses the greatest expansion of the mining industry known to our history. It is in the flood of this movement that the AMERICAN GEOLOGIST is consolidated with the new journal which is to be more closely linked with economic geology.

In looking over the published plans and purposes of the editors of the GEOLOGIST, the editors are constrained to admit that not all of their plans and promises have been accomplished; but it is with no feeling of regret or apology that they see some of their announced plans and hopes still unrealized. Some of the editors who evolved those plans have died, and new editors have substituted other contributions, which were probably equally within the scope of the journal.

We had aimed to issue short biographical sketches of all deceased American geologists, but in some notable instances our efforts have failed. Seventy such sketches have been published in the GEOLOGIST. We have had correspondence to this end concerning Lieber, Little, Rogers,

* In the reorganization of the New York Geological Survey, in 1903, there has been made provisions for the investigation and report on the economic geology of the state.

Marcou, Gesner, King, Vanuxem, Alexander, Percival, Brooks, Eames, and others, and have gathered some unarranged data. It is to be hoped that these efforts may be pushed by some one to future fruition. There is no better place to preserve the personality and the record of the scientific labors of geologists than in a sympathetic geological journal. This has been (or had been) neglected in the United States.

In laying down the active and responsible management of the journal the editors revert to the record of the past 18 years with satisfaction. They are sure that on the whole the influence of the published volumes has been wholesome. They fill a niche in the passing history of geology in America which, they trust, will be consulted with profit by the future student. The years 1888 to 1906 have been crowded with important geological research and with improvements in the methods of geological work, and the AMERICAN GEOLOGIST has contributed its quota to the progress that is so apparent. The editors wish to express their warmest thanks to the contributors who have co-operated with them, and to bespeak for the new editors the same cordial cooperation. N. H. W.

The first few years the GEOLOGIST was maintained with financial loss to the editors. Not counting anything for expense of editorial management, the GEOLOGIST has been self-sustaining for about ten years, and for the last five or six years there has been a surplus of a few hundred dollars annually above actual expenses, the largest annual surplus having been $542. The sole reason for surrendering this charge is the desire on the part of the managing editor, with advancing years, to find time for some other contemplated work. The GEOLOGIST, as a journal was never in as good condition as at the present time.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The secondary origin of certain granites, R A. DALY. (Am. Jour. Sci., vol. 20, Sept. 1905.)

This paper throws much light on the manner of origin of certain acid igneous rocks. In the prosecution of the survey of the international boundary between Canada and the United States, in the region between Port Hill, Idaho and Gateway, Montana, are found enormous thicknesses of quartzytes associated with argillytes. Dr. Daly here found numerous sills of gabbro lying parallel in the strata, some of the sills having a thickness of 2,500 feet, while the sedimentary rocks afford a total of about 20,000 feet of bedding exposed to geological study. The sedimentary rocks are divided into Creston quartzyte (at the bottom), the Kitchener quartzyte and the Moyie argillyte.

The sills, where in their present normal condition, were found to consist of hornblende gabbro, with some accessory quartz, titanite, biotite, and a little orthoclase. While this is not a gabbro it is assumed by the author to be the primary intrusive magma that entered the sedimentaries. These accessories increase as the rock varies from its original composition in the vicinity of the planes of contact with the sedimentary rocks, especially the orthoclase, quartz and biotite, accompanied, also, by microperthite. There is, further, a variation in the structural relations. The quartz becomes poikilitic to all the other constituents except the orthoclase and the microperthite, and with these it forms a micrographic intergrowth.

These phenomena are most marked in the greatest sills, the largest being denominated the Moyie sill, rather more than 2500 feet in thickness. While the quartzytes have been thoroughly metamorphosed, and especially feldspathized, near the sill, the gabbroid rock has been more profoundly altered. This alteration is most extensive along the upper contact of the sill, where the hornblendes are obliterated and in the place of labradorite is the feldspar andesine. Biotite is much increased in amount and soda-orthoclase also occurs, along with much quartz; microperthite, micropegmatyte, calcite, muscovite and epidote are also found along the contact. At fifteen feet from the upper contact hornblende is still wanting. The same is true of labradorite; oligoclase is 1.0 per cent, soda-bearing orthoclase is 32.5 per cent and quartz 41 per cent. There is also muscovite and titaniferous magnetite. At 50 feet from the upper contact, while hornblende and labradorite are still wanting, oligoclase constitutes 1.5 per cent and orthoclase 24.9 per cent. Quartz is here 57. per cent. and calcite 2.5 per cent. At 200 feet from the same contact hornblende is 49.4 per cent, biotite is

22. per cent, andesine is 16.5 per cent, oligoclase and soda-bearing orthoclase are wanting and quartz is 11.7 per cent. This variation continues to diminish toward the body of the sill until the endomorphic alteration fades out into the normal sill rock.

The rock at 15 feet from the upper contact belongs to the granite family. Toward the sill the rock varies more and more toward the gabbro type and toward the contact the variation is more and more toward granophyre granite. Xenoliths from the quartzyte present the same zones of metamorphism.

The author calls attention to similar cases of profound alteration at contacts of basic intrusives on siliceous clastic rocks in Minnesota and in Ontario, viz: at Pigeon point and at Sudbury, where have been described granitic and intermediate rocks resulting from such contact, acting themselves as igneous rocks and forming characteristic intrusions in the manner of dikes.

These phenomena are regarded by the author as demonstrating the assimilation theory at the points discussed. In his synthetic discussion he makes the following remarks:

"The secondary origin of granite has long been maintained by N. H. Winchell who has referred to the Pigeon Point case as among others, demonstrating the fact.* Bayley came to the same belief for the granite and granophyre of the point but he did not extend his argument in detail to cover other occurrences among the Minnesota intrusives. On the other hand the principle has not been accepted as applying to these localities even by Van Hise whose rare knowledge of Lake Superior geology must give his opinion exceptional weight.† Even the latest text books of geology give most inadequate treatment of the doctrine though it refers to one of the most important problems in the whole field of geology. Doubtless the majority of petrologists are to-day unfavorable to the assimilation theory of granite and its relatives except as it applies to a very limited, in point of volume insignificant, modification of certain magmas at their contacts.

"Van Hise's chief argument against the contact origin of the Pigeon Point granite emphasizes the fact that that rock has not the chemical composition either of the sedimentary formation or (as especially shown in the surplus of alkalies and the deficiency of iron in the granophyre granite) of a direct mixture of gabbro and sediments.‡ The much quoted argument of Brögger with reference to the Norwegian granites is based on a similar fact.§ Many other writers have, on a similar ground, excluded contact assimilation as playing any considerable part in the formation of abyssal or hypabyssal magmas.

"In practically every case the opponents of the assimilation theory have treated of the assimilation as essentially a static phe-

* Final Report, Minnesota Geological Survey, vol. 5, p. 62, etc., 1900.
† Monograph 47, U. S. Geol. Sur., 1904, pp. 730-733.
‡ Op. cit., p. 733.
§ Die Eruptivgesteine des Christianiagebietes. Pt. 2, 1895, p. 130.

nomenon. Each interpretation of field facts has been phrased in terms of magmatic differentiation versus magmatic assimilation as explaining the eruptive rocks actually seen on the contacts discussed. Nothing seems more probable, however, than that such rocks are often to be referred to the compound process of assimilation accompanied and followed by magmatic differentiation. The chemical composition of an intrusive rock at a contact of magmatic assimilation is thus not simply the direct product of digestion. It is the net result of re-arrangements brought about in the compound magma of assimilation. In the magma, intrusion currents, convection currents and the currents set up by the sinking or rising of xenoliths must take a part in destroying any simple relation between the chemical constituents of the intrusive and the invaded formations. Still more effective may be the laws of differention in a magma made heterogeneous by the absorption of foreign material which is itself generally heterogeneous. The formation of eutectic compounds or mixtures, the development of density stratification, and other causes for the chemical and physical resorting of materials in the new magma, ought certainly to be regarded as of powerful effect in the same sense."

The author mentions other defects in the arguments usually launched against assimilation, and concludes as follows:

"In the foregoing discussion the secondary origin of some granites has been deduced from the study of intrusive sills or sheets; but it is evidently by no means necessary that the igneous rock body should have the sill form. The wider and more important question is immediately at hand—does the assimilation-differentiation theory apply to truly abyssal contacts? Do the granites of stocks and batholiths sometimes originate in a manner similar or analogous to that just outlined for the sills?

"The writer has briefly noted general reasons affording affirmative answers to these questions.*

"Gabbro and granophyre are often characteristically associated at various localities in the British islands as in other parts of the world.† The field relations are not there so simple as in the case of the Moyie sill, for example, but otherwise the occurrence of many common features among all these rock associations suggests the possibility of extending the assimilation-differentiation theory to all the granophyres. Harker's excellent memoir on the gabbro and granophyre of the Carrock Fell district, England, shows remarkable parallels between 'laccolite rocks' and those of Minnesota and Ontario.‡

"At Carrock Fell there is again a commonly recurring transition from the granophyre to true granite, and again the granophyre is a peripheral phase. Still larger bodies of gabbro, digesting acid

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* Am. Jour. Sci., vol. 15, 1903, p. 269; vol. 16, 1903, p. 107.
† See A. Geikie. Ancient volcanoes of Great Britain, 1897.
‡ Quart. Jour. Geol. Soc., vol. 50, 1894, p. 311, and vol. 51, 1895, p. 125.

sediments yet more energetically than in the intrusive sheets, and at still greater depth, would yield a thoroughly granular acid rock as the product of that absorption with the consequent differentiation. This does not imply, of course, that all granites are of this origin, but it is quite possible that most intrusive granites are either of this origin or have been more or less modified through assimilation.

"The difficulty of discussing those questions is largely owing to the absence of accessible lower contacts in the average granite body. All the more valuable must be the information derived from intrusive sills. The comparative variety of such rock relations as are described in this paper does not at all indicate the exceptional nature of the petrogenic events signalized in the Moyie, Pigeon Point or Sudbury intrusives. It is manifest that extensive assimilation and differentiation can only take place in sills when the sills are thick, well buried, and originally of high temperature. All these conditions apply to each case cited in the present paper. The phenomena described are relatively rare largely because *thick* basic sills cutting acid sediments are comparatively rare.

"On the other hand, there are good reasons for believing that a sub-crustal gabbroid magma, actually or potentially fluid, is general all round the earth; and secondly, that the overlying solid rocks are, on the average, crystalline schists and sediments more acid than gabbro. Through local, though widespread and profound, assimilation of those acid terranes by the gabbro, accompanied and followed by differentiation, the batholitic granites may in large part have been derived.* True batholiths of gabbro are rare, perhaps because batholitic intrusion is always dependent on assimilation.

"The argument necessarily extends still farther. It is not logical to restrict the assimilation-differentiation theory to the granites. The preparation of the magmas from which syenites and diorites, for example, have crystallized, may have been similarly affected by the local assimilation of special rock formations. The development of some of the anorthosites of the Canadian and Adirondack Archean was possibly conditioned on the digestion of part of the associated crystalline limestones by plutonic magma.

"The officers of the Minnesota Geological survey have shown that the same magma represented in the soda-granite and granophyre of Pigeon Point forms both dikes and amygdaloidal surface flows.† The assimilation-differentiation theory is evidently as applicable to lavas as to intrusive bodies. But demonstration of the truth or error of the theory will doubtless be found in the study of intrusive igneous bodies rather than in the study of volcanoes either ancient or modern.

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* Cf. R. A. Daly, op. cit.

† N. H. Winchell. Final report, Minn. Geol. Sur., vol. 4, 1899, pp. 519-22.

"Finally the fact of 'consanguinity' among the igneous rocks of a petrographical province may be due as much to assimilation as to differentiation."

Mr. Daly has certainly added an important chapter to the literature of the igneous rocks. The reviewer would suggest that probably the hornblende gabbro of the Moyie sill is itself a secondary rock, differing from true gabbro in the same direction as its contact phases differ from the body of the sill. The true gabbro of Minnesota was found to acquire hornblende and quartz, and often orthoclase, when it came into contact or contiguity with the acid sediments of the Animikie. It is quite possible and logical to suppose that a mass of true gabbro magma, in the lapse of time, lying beneath the earth's crust, or perhaps in contact with the lower part of the quartzytes discussed by Dr. Daly, would suffer such endomorphic changes on a grand scale as to afford large quantities of hornblende-gabbro, and nothing else, in case of later intrusion into the overlying sediments. N H. W

La Montagne Pelèe et ses èruptions, par A. LACROIX. Quarto, 650 pages, 30 plates. Paris, 1904, 238 figures.

This work is published by the Academy of Sciences, under the auspices of the ministers of public instruction and of the colonies.

On opening the volume the reader is presented, in the frontispiece, with a heliograph of perhaps the most wonderful natural scene ever photographed—the "burning cloud" of the 16th of December, 1902, at the point of its arrival at the sea. Its hight, as it fades away and breaks into the air above was 4000 meters, or somewhat more than 13,000 feet. Its wedge-shaped, boiling front seems to roll along on the earth, occupying the valley of the stream. At the sea-level its foot spurts out upon the water somewhat like the advance of the water of a tremendous comber after it has broken upon the beach. Its higher portions are more advanced than its foot, but throughout its front its convoluted shape is marked and preserved, rendering it apparent that the great mass is as distinct from the atmospheric air as the dark thunder clouds of mid summer. It is only in the rear of the cloud that its outlines are confused and lost. Certainly no similar volcanic phenomenon was ever before so truthfully and so vividly reproduced. Hovey and Heilprin have published numerous excellent views of these steam-ash clouds taken usually from near the crater and showing partially the wonderful convolutions they undergo. Lacroix's photo was taken from across the sea level, and includes the entire cloud from bottom to top. To the observer it must have presented a sublime and portentous aspect. Of the results of the devastation of such a death-dealing cloud, the destruction of St. Pierre, the author says:

"J' ai rapporté une impression inoubliable, non seulement des phénomènes grandioses et passionnants auxquels j' ai assisté, mais encore des infortunes dont j' ai été le temoin, des spectacles tragi-

ques de cette campagne de six mois, de ces longues chevauchées dans la ville détruite et sur cette Montagne Pelée, naguere veritable Eden, aujourd' hui terre ravagée, couverte d' un gris linceul de cendres, qui n' évoque plus que des souvenirs de désolation et de mort!"

The *burning clouds*, and the *dome* and spine formed at the crater are, according to Lacroix, the two capital new facts of the great eruption. The book contains a great many new things of minor importance, and new discussions, presented in the inimitable and clear style of Lacroix, but the treatment of those dominating scientific facts in vulcanism gives to the volume a unique value. The work is divided into three parts, not including a bibliography of the geology and geography of the volcanic islands of the West Indies, beginning in 1640 and concluding with late publications consulted even during the process of printing of the volume. The first part treats not only of the physics of volcanic activity but presents in detail the facts of the late eruptions. The second part is taken up with petrographic discussion of the ashes, bombes, lavas and all ejecta of the present and of past eruptions of Martinique, and by a comparison of these with similar rocks from others of the volcanic islands of the East Indies. Part three is devoted to certain minerals and rocks produced from the building stones and some artificial substances by the burning of St. Pierre.

Part 1 contains a mass of descriptive details, with numerous photographic illustrations. At the present we can refer specifically only to the dome and the burning clouds. As to the former the author says: "The present eruption has been characterized particularly by this fact, that the gaseous emanations and the ejection of solid matter have been through a single opening, above which was built up rapidly a dome of andesyte whence thereafter all the explosive phenomena arose. It will be seen later that this dome did not present a permanent yawning, crater-like opening during all the time that I studied it. If it had one, or several, during the paroxysms, which is quite likely, they were of very short duration. There is then, properly speaking, no crater of the present eruption, in the sense that one generally gives to the word crater. But this dome, in place of being raised from any point of the volcanic ground of Mont Pelée, has ascended from the depths of an old caldera, from an old explosive crater which, in the first weeks of the eruption, before the appearance of the dome, consequently played the role of a veritable crater. In fact there is an incasement of two successive volcanic formations, the products of different mechanism." The author, however, applies the term crater, in his descriptions, to that part of the old caldera which has not yet been filled by the solid mass of the dome, nor by the pieces that become detached from it. This view is quite different from that entertained by *Heil-

* The tower of Pelée; new studies of the great volcano of Martinique. ANGELO HEILPRIN, 1904, p. 34.

prin, who believes that the spine, or tower, consists of an ancient core or plug remaining since the last eruption, now dislodged and thrust upward by renewal of volcanic activity. Lacroix, however, in his *resume et conclusions*, (p. 643) details more specifically his theory of the origination of the celebrated spine. Thus:

"The mechanism of the production of *domes*, which are composed principally of rocks but little fusible (rhyolytes, trachytes, andesytes, phonolytes) in so many regions, remained to the present very obscure, no direct observation having as yet permitted the following of the steps of growth of this kind of volcanic mountain. We know now, by a concrete example, how such a dome is produced. The molten magma, reaching the surface, by means of some fissure, forms there a mass which is quickly surrounded by a solid shell. This carapace not only protects the interior against too rapid congelation but through the fissures formed in its surface by contraction exudes a frothy lava which adds, according to the internal pressure, intermittently new quantities of molten matter to the exterior. Thus it increases in hight and in size, a constant rocky mass bristling with asperitics, bounded by abrupt walls which rise in the midst of the talus of fallen pieces which are constantly increased by superficial crumbling. Materials ejected by the paroxysms of activity play a very insignificant role and often take no part in the constitution of such a dome.

"The dome thus constructed is not pierced by any yawning opening, permanent as a crater, but the paroxysmal explosions produce in it temporary openings which are again rapidly sealed. When the external shell becomes so firm that it cannot longer yield to expansion in all directions the internal pressure is locally effective at a limited number of points, producing then the extrusion of solid rocky masses which may rise as if drawn through framed orifices, forming needles which may reach the hight of several hundred feet, in the manner of that whose birth and growth I witnessed and examined day by day during several months. In the course of a single eruption the point of concentration of effective pressure may be displaced, forming thus successive spines, varying in form, dimensions and position."

The destructive agent of the eruption, the *nuèes ardentes*, are regarded as the result of explosion issuing from the flanks of the dome, at Mont Pelée, but from the depth of the open crater at Saint Vincent. The explosion furnished an enormous mass of gas and water vapor, released rapidly on reaching the atmosphere, carrying along a considerable quantity of solid matter of all forms. Instead of being always projected vertically these clouds roll with great swiftness down the slopes of the mountain. In the case of feeble eruptions gravity has a determining influence upon their course, but in great paroxysms they are moved more rapidly, due to the accumulated action of the initial projection and of gravity acting

in the same direction. At Mont Pelée the position of the orifice of escape of these gases had a preponderating influence on their direction.

"These clouds, possessing at their starting a high temperature which becomes slowly lessened, have a considerable mechanical and calorific force, which explains the complete annihilation of a large city and its inhabitants, as well as the extension of the destructive effects to the distance of ten kilometers from their point of origin."

The scientific world is under obligation no more to the French republic than to the French savant for this grand and most satisfcatory treatise. N. H. W.

Minerals in rock sections; the practical methods of determining minerals in rock sections with the microscope, especially arranged for students in technical and scientific schools. LEA MCILVAINE LUQUER, Adjunct professor of mineralogy, Columbia University, New York City, Revised edition. New York, D. Van Nostrand Company, 1905. 147 pages, $1.50 net.

This revision of a useful and well-known text book has been improved by an enlargement of that part relating to the determination of the plagioclases, by the explanation and illustration of the Becke method of relative refraction in contiguous minerals, and by many additions in chapters I, III and IV; also by tables of refractive indices, of double refraction, and a diagram showing the relation between strength of double refraction, interference colors and thickness of section, the last being an adaptation from Michel Lévy's color scheme of double refraction accompanying *Minéraux des Roches* by Lévy and Lacroix. N. H. W.

Geology of Western Ore Deposits. ARTHUR LAKES, late professor of geology at the Colorado School of Mines; New Edition, entirely rewritten and enlarged, with 300 illustrations, 438 pages. Kendrick Book and Stationery Company, Denver, Colo., $2.50, postpaid.

Colorado has the chief share in this work, although its descriptions range from Alaska southward. It is well illustrated, frequently by sketches by the author, and its statements are correct and clear. The extended acquaintance of the author with the mining and methods of the Rocky mountain region has contributed a large share to the contents of this book though it is still largely, and necessarily, a compilation from other authorities—Emmons, Spurr, Weed, Van Hise, Kemp and others. The book cannot fail to be of great usefulness to the mining industry of the west. N. H. W.

Grundzüge der Gesteinskunde; 1 Teil, Allgemeine Gesteinskunde als Grundslage de Geologie. ERNST WEINSCHENK, mit 47 Textfiguren und 3 Tafln. Seiten 163, 1902, 4 marks. Freiburg, Wein, Strass-

burg, München, St. Louis, Mo., B. Herder: *II Teil, Spezielle. Gesteinskunde mit besonderer Berüsichtigung der geologischen Verhältnisse*, mit 133 Textfiguren und 8 Tafeln. Seiten 331, 1905, 9 marks, Freiburg, Wien, Strassburg, München und St. Louis, Mo., B. Herder.

These volumes are comparisons of the same author's *Gesteinsbildenen Mineralien* and *Anleitung zum Gebrauch des Polarisationsmikroskops* which are well known petrographical text books. Together they constitute a series by a single author covering the whole field of lithology. It is sometimes an advantage to a student after he has become familiar with the terms and usages of an author to be able to transfer his attention to another branch of the science without the necessity of acquiring the ready use of a lot of new terms.

Part I. contains a resumé of the known distribution and *mise en place* of the different kinds of rock masses. It has little to do with the composition of rocks, but describes vulcanism and the forms of rock masses it produces, the first crust of the earth and the crystalline schists, magmatic differences, rock-weathering, denudation, nature and distribution of sediments, eolian and alluvial deposits, marine sediments, glacial deposits, metamorphism, its agents, and its products, both contact and regional, and all forms of rock structures. It has a full and useful index.

Part II. treats of rock species, going through the whole gamut from granite and gabbro to the sedimentary rocks whether mechanical, chemical or organic, with a good index. A special chapter is devoted to the crystalline schists.

Both these parts are well illustrated with half-tones from photographs. The German is simple and easily read by a novice in that language. The work is distinctively a German production, with little reference to English and French literature. N. H. W.

Structural and Field Geology. JAMES GEIKIE Murchison, professor of Geology and Mineralogy in the University of Edinburg, for students of pure and applied science. New York. D. Van Nostrand Company, 1905, pp. 435, 56 plates and 142 illustrations in the text. $4.00, net.

This book is remarkable for two things—it has no references to authorities, and it does not touch on paleontology. It is what its title implies—structural and field geology—yet some might query whether it would have been, under that title, as reasonable to omit all reference to the mineral composition of rocks as all reference to their organic contents. Still, it is plain that the author had an idea, which he has tried to exemplify in his work. It is, further, very reasonable that a Scotch text-book on geology should reflect the dominant geological features of Scotland, and these certainly are not paleontologic. The illustrations are also taken from Scotch geology.

There are two other features which this book possesses which give it a unique character. These consist of detailed directions for geological surveying, i. e., the *how* and *what* to observe, and the methods of making maps and sections. These are essential to the equipment of a field geologist. It is necessary that the field geologist be expert in interpreting and expressing the significance of the topographic features. In the chapter on the "Economic aspects of Geological Structure" is a thorough discussion of underground water.

"This handbook addresses itself," as the author states in the preface, "in the first place to beginners in field geology, but I hope it may be found useful also to students who are preparing for professions in which some knowledge of Structural Geology is of practical importance." It is not therefore a handbook for the experienced geologist, dealing with geological problems, and investigations up to date. It only summarises the recognized fundamentals of geology. N. H. W.

Economic Geology of the United States, HEINRICH RIES, Asst. Professor of Economic Geology at Cornell University, pp. xxi, 435; plates 26; fig. 97. The Macmillan Company, New York, 1905. Price $2.60, net.

This work, which is intended to serve as an elementary textbook for students of economic geology, treats of the mode of occurrence, distribution and uses of both the non-metallic and the metallic minerals and rocks in the United States which are of economic value.

The book is divided into two parts: Part I. treating the non-metallic minerals, and Part II. the metallic minerals. This arrangement, which is perhaps different from that usually followed, has been adopted, because the non-metallic minerals produced annually have a greater aggregate value, and also for the reason that this line of discussion leads from the simpler to the more difficult part of the subject.

Although an elementary work, the book contains also extensive lists of reference so that those desiring to pursue the subject further can do so. These references are grouped at the end of each chapter where they can be easily referred to by those needing them, but at the same time, by this arrangement they take up but little space in the book.

In treating each mineral the aim has been to discuss its general characters and economic value, followed by a description of a few localities which are of importance or may serve as types, rather than to give a mass of detailed descriptions, which often tend simply to confuse the student.

The difficult task of presenting in one volume of moderate size a description of the mineral resources of the United States, and of allotting to each subject the proper amount of attention, has been unusually well performed. The space given to non-metallic minerals covers 215 pages, while 194 pages are devoted to metallic ores

and minerals. The value of the book for reference is greatly enhanced by a good index. The authorities quoted are up to date, and chosen with discrimination.

A work of this nature will probably never be entirely free from inaccuracies. As an indication of conscientious work on the part of the reviewer and for the correction of future editions it may be well to call attention to a few slips: Thus, corundum is not really, next to diamond, "the hardest abrasive known" (p. 163). An important use for sulphur not mentioned (p. 198) is in the manufacture of paper; and zinc is largely used in the cyanide process of gold extraction (p. 320). Fault planes and sheer zones can hardly be called "cavities" (p. 231), although they may permit the circulation of waters underground. This idea resembles the old notion that "fissure veins" were once open, empty cracks of indefinite vertical and horizontal extent. It is also true that "crustification" is often observed in veins which are *not* "formed by the simple filling of a fissure" (p. 236).

Tellurides are not "unknown," but are often found at the contact of granitic intrusions and calcareous rocks (p. 235).

The "apex" of a vein may not "outcrop"at all (p. 238). "Ore bodies lacking in iron pyrites," but composed of chalcopyrite do sometimes show secondary enrichment (p. 245). Some blast furnaces now use more than 75% of Mesabi ores in their charge (p. 265); and the greater value of hematite ore is not due so much to its proximity to theoretical purity as to the readiness with which it is reduced by carbonaceous fuel as compared with magnetite (p. 252).

Altered copper ores are *not* usually more cheaply treated than sulphide ores, and chalcopyrite is not commonly considered a secondary ore (p. 281).

The large copper mines at Butte are from 2000 to 2500 feet deep instead of 1000 to 1500 and the vertical limit of the silver ore was determined long before the silver mines reached the depth of 1400 feet (p. 286). Douglass Houghton was an "A. B." and "M. D." and a geologist, but it is novel to hear him called "a mining engineer" (p. 287). Copper in the Lake Superior region is seldom if ever "refined electrolytically" (p. 290).

Sulphide of gold is certainly a rarity (p. 329); but so are really well-balanced works on economic geology in general. And the conclusion should not be drawn from the above series of minor corrections and suggestions that this is not a very valuable and useful addition to our literature on the subject which it treats. Necessarily condensed, it yet covers the ground in a thorough and authoritative manner and will be used by many as the most satisfactory text book available. H. V. W.

MONTHLY AUTHOR'S CATALOGUE

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Notes on certain hot springs of the southern United States. (Wat. Sup. Ir. Pap., 145, pp. 185-206, 1905.)

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Determining of the optical character of birefracting minerals. (Am. Jour. Sci., vol. 22, pp. 285-296, October, 1905.)

CORRESPONDENCE

TWO CARBONIFEROUS GENERA.—I notice that two generic names appear to be in use for Carboniferous fossils (c f. Weller, Bibl. Index, N. Am. Carb. Invert.) are homonyms, and untenable.

(1) *Microdon*, Conrad, 1842 (Mollusca); not *Microdon*, Meigen, 1803. The name *Cypricardella*, Hall, is available. The species (following Weller) will stand as *Cypricardella bellistriata* (Conrad), *C. connata* (W cott), *C. elliptica* (Whitfield), *C. eximia* Miller & Gurley *C. gorbyi* Miller, *C. nucleata* Hall, *C. oblonga* Hall, *C quadrata* White & Whitfield *C. reservata* (Hall), *C subelliptica* Hall.

(2) *Prestwichia*, Woodward, 1867 (Crustacea); not *Prestwichia*, Lubbock, 1863. The name *Euproops*, Meek, is available for this genus. The species are *E. colletti* White, *E. danae* (M. & W.), and *E. longispina* Packard.

Goniodon, Herrick, 1888 (Mollusca), would be rejected by those who rejected *Calamodon* because of *Calamodus* (of Palmer, Index Generum mammalium, p. 151), as *Goniodus*, in fishes, is of course much earlier. This, however, is an extreme view, hardly likely to prevail. In the *Index zoologicus* Herrick's *Goniodon* is omitted, but there is cited a *Goniodon*, Perrier, in Echinoderms, without date. (c f. also Gregory, in Bather, Treatise on Zoology, part iii, p. 253.)

T. D A. COCKERELL.

University of Colorado, Boulder, Colo.

PERSONAL AND SCIENTIFIC NEWS.

MR. EDWARD H. BERRY, paleobotanist and secretary of the Torrey Botanical Club, is engaged in studying the fossil flora of Maryland for the Geological Survey of that state. His address is "Geological Survey, Johns Hopkins University, Baltimore, Md."

DR. W. B. DAWSON, brother of the late Dr. Geo. M. Dawson, is making a tidal survey of the Pacific coast of Canada.

DR. ROBERT BELL, is making a trip via Skagway to Dawson, in Yukon territory.

DR JOSEPH HYDE PRATT, of the North Carolina Geological Survey, is on an extended trip in Arizona and Montana, examining mining properties.

AT HARVARD UNIVERSITY Messrs. R. Kent and H. N. Eaton have been appointed assistants in geology.

THE NEXT MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCMENT OF SCIENCE will be held at New Orleans. It has been ascertained by the permanent secretary that by Dec. 29, in the judgment of public health and hospital officials, all danger from yellow fever will have disappeared.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—It has been decided by the corporation of the Institute that the plans entertained for some time past for the consolidation, or "cooperation" of the Institute with Harvard University, have to be abandoned, owing to the late decision of the supreme court relative to the land on Boylston street. In a circular lately issued by Pres. H. S. Pritchett the friends of the Institute are invited to hearty cooperation in its future upbuilding.

DR. H. W. FAIRBANKS of Berkeley, California, recently made a horseback trip with his wife and little daughter, from the Dalles in Oregon to San Francisco, passing over the highest ranges of the Sierra mountains, incurring many of the hardships and perils of camp life. It was for photographing the topographic and geologic features preparatory to a new work on which he is engaged.

WEIGHT OF BRONTOSAURUS. From measurements and estimates made at Columbia University by Prof. William Hallock and W. K. Gregory, upon a restoration of Brontosaurus excelsus made by Charles R. Knight, the saurian was found to have had a weight of about 38 tons. The mounted skeleton, at the American Museum of Natural History, is 66 feet 7 inches long.

DR. C. R. J. LAFLAME, president of the Royal Society of Canada has been appointed by the international water-

ways commission to make a report upon the recession of the Canadian side of Niagara falls.

"ECONOMIC GEOLOGY" is a new semi-quarterly journal devoted to geology as applied to mining and allied industries, the editor of which is Prof. John Duer Irving, Lehigh University, South Bethlehem, Pa. Its first number is dated October-November, 1905. It is an octavo of 100 pages. Associate editors are Waldemar Lindgren, James Furman Kemp, Frederick Leslie Ransome, Heinrich Ries, Marius R. Campbell and Charles Kenneth Leith.

A MEETING OF THE MEMBERS OF THE DIVISION OF HYDROLOGY of the United States Geological Survey who are engaged in the artesian water and related geologic investigations was held in Washington Saturday, December 9th, for the purpose of organizing a society for the discussion of problems relating to underground waters and methods of increasing the efficiency and economic value of investigations. Among those attending the meeting were F. H. Newell, Chief Engineer of the Geological Survey, and officials and members of the division of hydrology. The formation of the new society was decided upon, but the details of organization were left to a future meeting.

THE HAYDEN MEMORIAL GOLD MEDAL was awarded November 7 by the Academy of Natural Sciences of Philadelphia to Dr. C. D. Walcott Director of the United States Geological Survey.

DR. C. H. GORDON, lately of the New Mexico School of Mines, is occupied in the study of the geology and the ore deposits of certain districts in New Mexico for the United States Geological Survey.

THE EIGHTEENTH WINTER MEETING of the Geological Society of America will be held at Ottawa, Can., Dec. 27-29, 1905. The President is professor R. Pumpolly.

ERRATA FOR VOLUME XXXV.

The plate facing page 104 should be numbered x. Page 245, line 5 from the bottom, for "inspection" read instruction. Page 404, line 4 from the bottom, for xxxiv read xxxv. Page 285, line 18, for "they" read three.

ERRATA FOR VOLUME XXXVI.

Page 187, line 62 for "W. U." read G. F. M. Page 250, in the "Editorial Comment" all references to the plate should read plate xiii instead of "plate xvi," and the title should read Willamette instead of "Williamette."

AMERICAN GEOLOGIST

DECEMBER, 1905.

Index for Volumes I-XXXVI.

EXPLANATION. There are general heads under which titles are grouped, viz: Cretaceous, bibliography, geology, etc. Titles relating to minerals are divided into two groups, viz: those referring to mineral species, generally "reviewed", and those relating to economic or other aspects. In the former group the authors' names are not given; in the latter they are. "Fossils" are also divided into two groups, viz: paleontological papers "reviewed", and papers consisting of original descriptions of species.

In all cases the arrangement of titles under the general heads, and under the groups, is chronological and not alphabetical.

The index is not an alphabetical one, with many cross-references, but, under a general alphabetical regimen it is geographical and chronological. Subjects relating to each state are grouped under the name of the state: but all the Canadian states, including Newfoundland, are listed under the head of "Canada".

ABBREVIATIONS. (abs)=abstract; (Am. com)=Report of the American committee at the International Congress of Geologists, at the London session, 1888; (cit.)=cited; (rev.)=reviewed; (rem.)=remark; (p. s. n.)=personal or scientific note; (ed com.)=editorial comment; (obit.)=obituary notice.

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Page 320, line 6, for "comparisons" read companions.
Page 332, line 4 from the bottom, for "62" read 26.